Bunker Hill Lead Smelter
Bradley rail siding
Kellogg
Shoshone County
Idaho

HAER No. ID-29

HAER
ID
40-KELL,
2-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Western Region
Department of the Interior
San Francisco, California 94107

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HISTORIC AMERICAN ENGINEERING RECORD

BUNKER HILL LEAD SMELTER HAER No. ID-29

Location:	Bradley, near Kellogg, Shoshone County, Idaho U.S.G.S. 7.5 minute Kellogg West, Idaho quadrangle, Universal Transverse Mercator coordinates: 11.563640.5265700, 11.563340.5265380, 11.562850.5265490, 11.563200.5265820
Date of Construction:	1916-1917. Additions 1924, 1925, 1926, 1927, 1939, 1941, 1943, 1945, 1953, 1966, 1970, 1977, 1978, 1980. Altered 1950, 1956.
Consulting Metallurgist:	Jules Labarthe
Builders:	Bradley, Bruff, and Labarthe Rojette, Forbert, and Winter Kansas City Structural Steel Company Alphons Custodis Chimney Company Bunker Hill & Sullivan M. & C. Company Allis-Chalmers Manufacturing Company Bonnot Company Buffalo Forge Company Dwight & Lloyd Sintering Company General Electric Company H. K. Porter Company Ingersoll-Rand Company Link-Belt Company M. H. Treadwell Company N. D. Phelps (Knight Woolen Mills) Pawling-Harnischfeger Company Traylor Engineering & Manufacturing Co. Westinghouse Electric & Manufacturing Western Precipitation Company Youngstown Steel Car Company Leonard Construction Company Lurgi Corporation Monsanto Corporation National Lead Company
Present Owner:	Pintlar Corporation, Ksllogg, Idaho
Present Use:	Idle lead smelter, scheduled for demolition in 1994
Significance:	In the face of opposition by the Guggenheim "Lead Trust," the Bunker Hill Company's president, Frederick Bradley planned and executed the building of a lead smelter, with the assistance of his local manager, Stanly Easton. This plant's output of commercially pure lead made it a significant contributor of this widely used material during nearly sixty- five years of operation.
Report Prepared By:	George D. Domijan Historical Consultant Jasberg Technical Services 1005 McKinley Avenue Kellogg, Idaho 83837
Date:	August 1993

I. Historical and Descriptive Narrative

A. Historic Background- Lead Smelting and the Coeur d'Alene Mining District of Northern Idaho

The 1883 gold rush that attended A.J. Prichard's letters of discovery to his friends in the Liberal League brought thousands of hopeful prospectors to the placer workings near Murray, Idaho.[1] In the quest for a stake in the mineral wealth of the area, their searches spilled over the divide that separated the North Fork of the Coeur d'Alene River from its southern drainage, and the miners encountered rich outcroppings of ore in several of the side canyons that fed into the main valley of the South Fork of the Coeur d'Alene River.[2] Two of these claims, the Bunker Hill and Sullivan, were to become the basis of the mining company of the same name. Their location in 1885, and subsequent sale to Portland financier Simeon G. Reed in 1887, were predicated on the existence of a rich galena (lead sulfide bearing) orebody. Its initial mineral output was obtained by hand-sorting high grade from gangue material, but this was soon supplanted by a mill for the comminution and beneficiation of lower grades of ore. Both classes of galena required further reduction in lead smelters, to free the lead from the undesirable sulfur (which was fumed off during the roasting process), and to pyrometallurgically smelt and refine the lead until it was ready for marketing as commercially pure. The Bunker Hill & Sullivan, along with the other mines of the Coeur d'Alenes, were dependent on the operations of these smelters, which were outside of the district, and, after 1886, accessible by rail. The costs of haulage and the smelters' margin of profit acutely affected the ability of mines like the Bunker Hill to realize a financial gain. The small operators were soon bought out and their properties consolidated by monied capitalists like Reed, who were able to withstand the economic swings of mining and realize a profit on high volume production of the lower grades of ore.

Control of a smelter would relieve a mine operator of dependence on smelting concerns outside of the company, and, if it were well situated, could greatly reduce haulage fees. Frederick Bradley, who had hired on as a construction engineer with Bunker Hill in 1890, and succeeded to its presidency in 1897, achieved this beneficial situation with the purchase of a smelter in Tacoma, Washington in 1898.[3] It was located at a seaport (which favored inexpensive barge transport of concentrates from Bradley's Alaska Treadwell Mining Co.), and it was relatively close to Bunker Hill's Kellogg, Idaho mining operations, compared to facilities like the Selby Smelter in Benicia, California, and the smelting works in Colorado and elsewhere. The Bunker Hill & Sullivan Mining and Concentrating Company was in the advantageous position of controlling its product from raw ore to smelted bullion. The successful rehabilitation and operation of the Tacoma smelter enhanced the company's balance sheet and caught the attention of the Guggenheim family, who were achieving prominent status within the lead smelting industry through their company, American Smelting and Refining. It was their intention, in this age of industrial trusts, to control as much of the smelting market as they possibly could. Accordingly, Bernard Baruch mediated the sale of Frederick Bradley's Tacoma smelter to A.S.&R. in 1905, solidifying the Guggenheims' position as the "Lead Trust." Along with the Tacoma purchase, A.S.&R. obtained Bunker Hill ore for twenty-five years under the terms of a smelting contract that provided for adjustments every five years.[4]

The ore that came out of the Coeur d'Alenes, especially from properties like Bunker Hill and the Tiger-Poorman Mine in Burke Canyon, was especially desirable for smelting operations as it was high in lead and low in silver, thus useful in blending with ores that were "dry" (low in lead content).[5] Besides being a product with a wide variety of commercial applications, the lead acted as a "collector of silver," which enabled the smelters to efficiently extract silver from the "dry" concentrates that carried high values of this metal.[6] American Smelting and Refining recognized the importance of concentrates from the Coeur d'Alenes, both as a valuable constituent of their smelters' feed and as a major source of production that they needed to incorporate into their plans for monopoly of the smelting industry.

From the perspective of the mining companies, however, formation of a smelter trust would eliminate the competitive market for their metals, and the resultant price control of lead would effectively tether them to A.S.&R., thus compromising their independence. One of the major figures of the early days in the Coeur d'Alenes, Charles Sweeny, attempted to establish a local mining monopoly with the backing of the Rockefellers. The Federal Mining & Smelting Company, chartered on June 24, 1903, was part of his plan to compete with A.S.&R., but his stated intention of reviving an idle Everett, Washington smelter (owned by John D. Rockefeller) was short-circuited by American Smelting and Refining's purchase of the smelter on November 15, 1903.[7]

Another Coeur d'Alene District mining man, Wilbur Greenough was interested in the erection of a local smelter to treat the output from Day Mines' Hercules Mine, near Burke. He approached his co-owner Harry Day, along with Bunker Hill's Frederick Bradley and his local manager, Stanly Easton about this possibility, but the Guggenheims had enough of the district's ore tied up in long-term contracts (similar to Bunker Hill's), that it would be difficult to line up sufficient feed for their independent smelter, and these discussions were discontinued by the end of 1908.[8] Day Mines hadn't given up on the idea of a company-owned smelter, however, and when their contract with A.S.&R. came up for renewal in 1915, they struck off on their own by purchasing an idle smelting facility near the Canadian border, at Northport, Washington and the Pennsylvania Smelting Company, at Carnegie, Pennsylvania for its refinery and marketing facilities.[9]

The Bunker Hill & Sullivan Company's 1905 contract with American Smelting and Refining specified that A.S.&R. would handle Bunker Hill concentrates containing 30% to 75% lead, up to thirty-seven tons daily.[10] Bradley took this to mean that his company was free to market concentrates that fell outside of those percentages wherever they chose to, and he soon had his mill superintendent, Gelasio Caetani, working to perfect the milling process to produce high percentage concentrates on a regular basis. The experimental work, carried out in the company's South and North Mills, showed sufficient promise to justify the building of a new West Mill in 1909.[11] The Guggenheims objected to this reading of the contract, obviously, and it became a bone of contention between the two companies for the first ten years of the contract.

The state of affairs between Bunker Hill and A.S.&R. reflected the general attitude of mine operators and smeltermen regarding each other, one which James E. Fell, Jr. characterized as ranging from "lukewarm to strident."[12] Frederick Bradley expressed this same skepticism when he sought to engage the services of a Spokane, Washington attorney, Myron A. Folsom in interpreting their contracts with American Smelting and Refining: "As you know the mining companies and the smelting trust have always conducted negotiations at arms length and the smelting company has always had the advantage of keeping all its direct and indirect charges in a very muddled up condition so as to confuse the mine owner."[13] Bradley was concerned that the Guggenheims' organization intended on raising the fees they charged to Coeur d'Alene District mines, all of whose contracts with A.S.&R. were subject to renewal in 1915. He and Easton hoped to secure the most favorable rate possible for Bunker Hill, and their strategy was to impress the Guggenheims with Bunker Hill's seriousness in seeking other sources of processing if they weren't treated fairly by A.S.&R. This included investigation of an electrolytic alternative to lead smelting and reopening the topic of an independent smelter for discussion.[14]

In September, 1914, Folsom was enlisted to contact International Smelting and Refining regarding the building of a smelter, but they had just recently closed their Spokane office. Fortunately, he was able to speak with a Mr. Goodell, formerly employed by International there, who had worked on the planning for a proposed smelter at Saltese, Montana, just over the state line from the Coeur d'Alenes. Goodell was convinced that it could be a profitable operation, and he had already gained the receptive ear of Hecla Mining Company's James McCarthy. Folsom urged Goodell to speak to Stanly Easton.[15] Bradley was encouraged by this news, and he later noted in corresponding with Folsom that "we surely have a good club with Goodell and his local smelter ideas."[16] It was but a short step for Bradley and Bunker Hill to move from using the idea of an independent smelter as a bargaining tool, to laying out the plans for a company owned smelter. In 1915, the Bunker Hill & Sullivan Mining and Concentrating Company made that step.

B. Historic Background- The Bunker Hill Lead Smelter: Feasibility and Location of a Company Owned Plant

On June 30, 1915, Jules Labarthe, of the San Francisco engineering firm Bradley, Bruff, and Labarthe, issued a report regarding the feasibility of Bunker Hill building a lead smelter and refinery. Frederick Bradley had commissioned this study, which reaffirmed Goodell's proposition regarding the economic viability of a local smelter. Labarthe estimated that such a plant could recover 95% of the lead in the concentrates and 97% of the silver, underscoring his "opinion that it would be more profitable for your company to build and operate a smelter and refinery than continue shipping your product at the present rate charged for freight and treatment."[17] As part of his report, Labarthe briefly compared the advantages and disadvantages of siting the facilities at either Kellogg, Idaho or Portland, Oregon, and he described the layout of a smelting plant and refinery (projected costs $800,000 and $200,000, respectively).[18] Besides the necessary process equipment, a smelter's physical plant would consist of a sampling mill, storage and charge bins (for the concentrates, fluxes, and coke), sintering plant, blast furnaces, power house, fume recovery and emission system (brick flue, baghouse, and stack), assay office and laboratory, warehouse, machine and carpenter shops, pumping plant, and employee housing. The refinery would contain all of the equipment necessary to separate the lead and silver from the other constituents of the lead bullion obtained from the blast furnaces. Bradley took note of the report's cost figures, and conveyed his favorable impression to Stanly Easton, saying that "I told Wm. H. Crocker total cost $1,000,000 and money back in six years."[19] Crocker was a director and member of Bunker Hill's executive board, and he served as the company treasurer.[20]

Although Labarthe favored Kellogg over Portland because of the economics of a short haul of concentrates and the lower likelihood of smoke damage claims in a sparsely populated, non-agricultural area, Bunker Hill commissioned a second report by Labarthe's firm regarding plant location to thoroughly assess the factors pertaining to various sites in the Northwest. The Puget Sound and Portland locations had much to offer in the way of labor savings, lower power rates, and freighting options, but Kellogg possessed the powerful trump card of a short haul of the large tonnage required for smelter feed. Its major disadvantage lay in the lack of a competing rail line, as the only trackage in the Kellogg area was owned and operated by the Oregon and Washington Railway and Navigation Company (a Union Pacific subsidiary). Despite this, Labarthe pushed for Kellogg as the location, emphasizing the importance of doing "everything possible to secure an additional line of railway from Kellogg as more can be accomplished in overcoming the obstacles and in securing fair and reasonable rates, in this way than by any other means."[21]

Engagement of Bradley, Bruff, and Labarthe to investigate the option of a company owned lead smelter was not a closely held secret. It was part of Bradley and Easton's planning to make A.S.&R. aware of their dissatisfaction with the present smelting arrangements, and the industry took note of the issue in one of its main publications, the Engineering and Mining Journal, which duly reported not only the defection of the Hercules (with their smelter purchase in Northport, Washington), but the Bunker Hill's intention of building a lead smelter: "This is a more formidable insurrection in the lead-smelting business than the A.S.&R. Co. has ever had to face...it is but natural that these big mining companies should want to do their own smelting. That they are taking steps in that direction is an interesting and healthful development."[22] The Guggenheims, of course, did not find this turn of events particularly healthful to their smelting enterprise, and their intention of preventing a Bunker Hill smelter from operating was brought home to Frederick Bradley by one of Bunker Hill's New York stockholders, who warned of "the rage of the Smelting people," and the "lawsuit which is at once to be brought against you for breach of contract."[23] Undaunted, Bunker Hill pressed on with their preparations, formally selecting Kellogg, Idaho as the site, a decision reported by the Spokesman-Review on April 1, 1916, and roundly welcomed by the Spokane Chamber of Commerce. Their chairman, Charles Hebberd, expressed the Chamber's gratification "that this industry is to be located in the Inland Empire rather than going to the seaboard."[24]

American Smelting and Refining brought a lawsuit against Bunker Hill on the grounds that Bradley had been warned of, but the decision that was handed down by the court didn't stop the Lead Smelter from going forward. The legal representatives of Bunker Hill and A.S.&R. then entered into discussions that were formalized as an agreement, retroactive to March 1, 1918, that split Bunker Hill's concentrates between the two parties for the duration of the contract, until 1930.[25] Myron Folsom's thorough preparation in defending and negotiating for Bunker Hill mirrored Bradley's and Easton's efforts in planning the Lead Smelter, which came into production less than a year after construction had begun.

C. Building the Bunker Hill Lead Smelter 1916-17

Stanly Easton's report to the stockholders for 1915 announced the commencement of construction on "a modern smelting plant at the mine," although, in fact, the Lead Smelter was taking shape on a ridgepoint above the rail siding of Bradley, a mile to the west of the Bunker Hill Mine.[26] The site had been prepared, with benches cut into the slope for the various elements of the complex, and much of the equipment needed was at hand or in the process of being procured. The all important consideration of an ore supply for the plant led Myron Folsom into discussions with the Hecla Mining Company's president, James McCarthy, and he wrote to Bradley that

McCarthy "was prepared to go with us to the limit," provided that he could enter into a one-year contract with International Smelting and Refining for processing Hecla's concentrates.[27] McCarthy was successful in his arrangements with International, and, along with that source and the Bunker Hill's strong ore reserves, Easton was able to line up sufficient ore supplies to guarantee operation of the Lead Smelter and Refinery. Early in Bunker Hill's investigation of the subject, it was apparent that if the company was willing to undertake the cost of building a smelter to produce lead bullion, further profits could be realized from the operation of a companion refinery to produce a finished lead product. Folsom had been approached by Mr. Wraith, the manager of International Smelting and Refining, in regard to the Lead Smelter's bullion, expressing an interest in refining the product, but Folsom had let him know of the Company's intention of doing their own processing. Wraith encouraged them in this, backing up Labarthe's recommendations by saying that the day of the custom smelter was passing, and that the location of a smelter should be as "near the collar of the mine shaft as possible."[28]

The plant that was being built on the site of the former Bingham Ranch was very near to the Bunker Hill Mine, but it was situated far enough from Kellogg to alleviate smoke settling over the town, something that Goodell noted when he examined the area in 1915, and which he wrote in favor of, remarking that "smoke will seldome [sic] if ever go any where but up little draws and gulches to top of range, following a course over property owned almost exclusively by yourselves."[29] To superintend the construction, Bunker Hill contracted with the firm of Bradley, Bruff, and Labarthe, the compilers of the initial feasibility and siting reports. Jules Labarthe was designated as the "Consulting Metallurgist...during the construction of and 'Blowing in' of the said metallurgical plant."[30] His duties involved him in details of construction far in excess of what his straightforward title implied.

Initially, basic issues like power generation (particulars and siting), arrangement of buildings and railway linkages, estimates of building materials, construction personnel needed, and limestone (for use as flux in smelting) availability were the subjects of correspondence between Labarthe and Easton. In May, 1916, Easton wrote regarding the Lead Refinery and its track. His engineers informed him that the facility was ten feet too close to the tracks of the Sierra Nevada Mine highline (owned by O.W.R.&N.). Easton thought that a compromise could be struck, but that something would have to be cut off to make more room.[31] Labarthe responded with the suggestion that the Refinery track be positioned closer "by using a low trestle in front of the Refinery Building."[32]

Rail matters were a continuing concern of both Easton and Labarthe, as Bunker Hill was going to require a large amount of company-built trackage within the plantsite, yet still be dependent on the Oregon & Washington Railway and Navigation Company for shipment of product. In this instance, Easton wanted to induce Northern Pacific, whose western terminus in the Coeur d'Alenes was at Wallace, to build into Kellogg. In the absence of competition, he was uncomfortable with Union Pacific's rate proposal.[33]

Another problem related to transportation involved the large amounts of solid rock that would have to be removed in laying out the railroad grade through cuts in the spur ridges. Labarthe wanted to examine realignment to avoid rock, but Easton replied by telegram that this would demand exceptionally sharp curves, and that the resurveying would hold up the contracts that had already been let. He expressed his hope that "possibly cuts will not disclose as much solid rock as engineers estimate."[34] Labarthe's suggestion that they seek an outside contractor to do the grading (as opposed to accepting the $50,000.00 estimate of O.W.R.&N.) was favorably received, and Rojotte, Forbert, and Winter of Spokane submitted the low bid for the grading in May, 1916, subsequently agreeing to undertake the additional task of excavating the foundations for the Lead Smelter.[35]

As work proceeded, Labarthe was able to investigate metallurgical questions as they related to design features of the plant. A decision was made to "divide the flue so that it will be possible to keep the roaster gases separate from the blast furnace gases and conduct them to a different part of the Bag House."[36] By the end of 1916, a Cottrell treater was incorporated into the plant design to handle the more acidic gas coming off of the Dwight and Lloyd roasters (which produced the sinter for the blast furnace), thus sparing the woolen bags for recovery of fume from blast furnace gases.

Work on the Lead Smelter progressed steadily in 1917, and by summer the plant was nearly operational. They were awaiting the arrival of a slag car before starting up a blast furnace, which was projected for June 24, 1917, and had arranged for a railroad car of lead bullion from the Days' Northport smelter to blow in the blast furnace.[37] The bullion, a necessary part of the original furnace charge, was added into a blast furnace crucible that had been thoroughly fire-dried, cleaned out, then relighted. When a sufficient quantity of molten lead was present, a slag-tapping jacket was put in place within the furnace, and coke introduced to ignite on the bullion, the heat of ignition being maintained by air forced through openings (known as tuyeres) in the furnace. The addition of a charge (containing sintered material, coke, and fluxes) signaled the completion of blowing in the furnace. Continuous production of lead bullion was then initiated, with the slag material being periodically drawn off for disposal.[38] The Lead Smelter's June goal was slightly delayed, as the first blast furnace wasn't blown in until July 5, 1917.[39]

Completion of Bunker Hill's smelter occurred reasonably close to construction estimates, which was a remarkable feat, considering the number of contracts with a variety of suppliers that Labarthe and company had to oversee: Kansas City Structural Steel Co. was responsible for supplying much of the plant's steelwork; the Bonnot Co. provided machinery for a coal pulverizing plant (which was seen as an alternative to dependence on fuel oil); the Sintering Plant contained roasting equipment from the Dwight & Lloyd Sintering Co. (along with a roaster from the Wedge Mechanical Furnace Co.); Traylor Engineering and Manufacturing Co. built the three furnaces used in the Blast Furnace Dept.; Ingersoll-Rand Co. supplied a blower and other power equipment; Buffalo Forge Co. was the source of the Niagara Conoidal Fan in use at the Smelter Bag House; transfer of materials within the plant was accomplished through the use of cranes purchased from Link-Belt Co. and Pawling-Harnischfeger Co.; Allis-Chalmers Manufacturing Co. made the Faber du Faur retort furnaces and the English cupelling furnace used in the Lead Refinery; locomotives were purchased from H.K. Porter Co. and Westinghouse Electric & Manufacturing Co.; specialized cars and hoppers for the transport of materials came from M.H. Treadwell Co. and Youngstown Steel Car Co.; General Electric Co. electrical equipment was in use throughout the plant; an order of 1200 woolen bags from N.D. Phelps (representing Knight Woolen Mills of Provo, Utah) stocked the Bag House; an agreement with Western Precipitation Co. provided for licensing of the process used in the Cottrell treater; Alphons Custodis Co. built the perforated radial brick stack at the Lead Smelter; and a number of other firms supplied the operation with machine tool equipment, a winding engine, conveying equipment, centrifugal pumps, and ore feeders.[40] The completed plant represented a considerable accomplishment by the Company, its consultants, and contractors. Photograph ID-29-1 shows the plant in operation soon after its completion in 1917.

D. The Layout and Operations of the Original Lead Smelter

The original Lead Smelter had many component parts. T.A. Rickard gives a serviceable description of the general plant layout: "In the eastern hollow are the receiving bins, the crushing plant, and sampling-mill; in the west hollow are placed the charge bins; on top of the ridge between these two depressions are the roasters, track-scales, warehouse, shops, bag-house, Cottrell treater, and stack. Below them are the furnace buildings and the refineries."[41] A system of flues, fan and blower houses, and railroad trackage linked the pyrometallurgical facilities. Additionally, there were fuel and cooling water tanks, offices (main and assay), a "bluestone" plant (for crystallization of copper sulphate), Bonnot coal-pulverizing plant, and a change-house (also known as a "dry"). Ore concentrates entered the system at the receiving bins. If the material was unconcentrated high-grade, it would have to first be crushed. After sampling, the concentrates were ready for roasting.

Roasting was done in the Sintering Plant, which was situated below, and in front of the Bag House. Nine Dwight and Lloyd sintering machines and one Wedge roaster (for double roasting high sulfur content material) were available for production of sinter. Sinter was the term for the roasted concentrates that were introduced into the blast furnace, along with fluxes and coke. The concentrates were hopper-fed onto the moving pallet of the Dwight and Lloyd machines, and pulverized coal used to ignite the sulfur, which fumed off into a flue leading to the Cottrell treater. The sintered concentrate, dried and relieved of sulfur, passed through a water spray, which gave it porosity, to aid in blast furnace reduction. Photograph ID-29-2 shows the sintering process.

Use of these machines involved the payment of a royalty to the Dwight & Lloyd Sintering Company. The royalty was based on tonnage of concentrates processed for sinter. In these early days of operation, Bunker Hill sought to reduce the amount of crushed limestone that they were using as a flux, and they substituted an "iron middling product...from the Concentrator (mill). This product carries from 6% to 10% in lead, but we feel that it should be exempt from royalty, as it is used strictly in the nature of a flux."[42] The Dwight and Lloyd Company agreed to exclude these middlings from royalty charges, but they still desired to have it incorporated into the total tonnage sintered, reasoning that "due to changing metallurgical and market conditions, they may be true ores."[43]

Sinter, fluxes (limestone, siliceous ores, middlings, and dross) and coke were stored in the twenty-four charge bins on the western edge of the complex. From these, a charge was assembled for the blast furnaces. Hoppers fed the materials into the charge car, which traveled back along the track to the Blast Furnace Building, where its load was discharged into the top of the furnace. The blast furnaces were water-jacketed to protect the furnace walls from excess heat. As the charge entered the crucible, coke was ignited with blasts of air entering through the tuyeres to sustain combustion. There were ten of these four-inch tuyere openings per furnace.[44] The size of the furnaces ranged from 48 by 180 inches at the tuyeres to 45 by 180 inches at the crucible. During smelting, slag material separated from the lead bullion and rose to the top of the bullion. Periodically, this slag was "tapped" from above the bullion layer, which accumulated in the lead well of the furnace. From there, the bullion was drawn off into a brick-lined steel pot. The slag was run through 6-foot diameter settlers before discharging into slag pots. The slag pots were mounted on Treadwell cars, which were maneuvered by a small locomotive to the edge of a dump outside of the Blast Furnace building. The slag pot was emptied of its load at that point. The bullion pot was moved into the Lead Refinery by an overhead crane that traveled between the blast furnaces and Lead Refinery kettles. Fume from the blast furnaces entered into the brick flue, which ran up the hill into the Bag House.

The fume that entered the flue from the Blast Furnace Bldg. and from the Sintering Plant still contained metals that could be recovered and run back through the system. Entrained material in the Blast Furnace fume traveled in the gas stream through the brick flue to the Bag House. A separate flue directed the fumes from the Sintering Plant into the Cottrell treater.

The Bag House was a brick building, nearly 130 feet long and 50 feet high, divided into three sections.[45] Inside it, woolen bags (18 inches in diameter by 30 feet) were ranked, 400 in each of the sections. The bags were "woven from raw wool with the natural grease...retained in the yarn...and provided with a 6" hem on the lower end."[46] They were attached to a thimble floor above the cellars in the building. After Blast Furnace fume had been fed into a section, the bags were mechanically shaken, dislodging the accumulated dust into the cellar, from where it could be collected and recycled through the Lead Smelter's operating system. Smoke was vented out through the brick stack.

The Cottrell treater was built to handle the high sulfur fume exhausting from the Dwight & Lloyd machines. This gas was more acidic, thus more corrosive to the woolen bags. Instead, it exited the Sintering Plant via a steel balloon flue and spray chamber, before entering the upper deck of the brick flue, which connected with the Cottrell. Sixty-four steel pipes (12 inches in diameter by 16 feet) were verically arranged in the building. Each pipe had a steel wire or chain running the length of it. As fume entered the pipes, an electric current passed through the wire, charging the moistened particulate in the fume and causing it to be attracted to the pipe walls, while the gas vented out the Smelter stack. Accumulations of dust were removed by hammers that mechanically rapped the pipes every two hours.[47] As with the Bag House dust, this material was collected for retreatment. Bunker Hill operated the Cottrell treater under a license granted by the Western Precipitation Company, which held the patents for electrostatic precipitation of dust in fume. Photograph ID-29-3 shows part of the interior of the Cottrell treater.

Once the lead bullion had been collected from the Blast Furnace Department, it was dumped from its pot by a crane operator into a 50-ton drossing kettle (there were four of these in the original Lead Refinery). The kettle was heated to 1000° F. to melt whatever lead was contained in the dross, and a small addition of coal (by the shovelful) was used to "dry up" the dross that formed on top of the cauldron. Then the kettle was cooled to 650° and agitated with air to facilitate copper dross formation. This was skimmed off and the bullion pumped into another kettle for a second drossing. During the second dross treatment, sulfur was added to the kettle and mixed in. The bath was allowed to cool, and the dross that formed on its surface was skimmed and added to the previously collected copper dross for treatment in a 30-ton byproduct furnace.

The drossed bullion was then ready for pumping into one of three 75-ton, brick-lined softening furnaces. To soften the bullion, antimony had to be removed. Periodically, the Lead Smelter would produce a hard-lead, containing antimony, but the bulk of their output was soft, commercially pure lead. Drossed bullion entered the softening furnaces through a 75-foot long launder that was lined with "a mixture of two parts cement and five parts limestone."[48] During the course of the softening process, the furnace temperature was brought up to 1650° F., causing the antimony to oxidize as lead antimonate on the surface of the bath. When this process was complete, the furnace doors were opened, the bullion cooled, and the solidified antimonial slag was rabbled from the furnace into a slag pot.

The copper dross and antimony skim that had been removed still contained metal values, and these were made available through processing in the reverberatory byproduct furnace. The copper dross was charged into the furnace with silica, which fused and melted with the dross. Four layers formed in the bath: light slag, matte, speiss, and bullion. The slag and bullion were returned to the blast furnace and drossing kettle, respectively, while the matte and speiss were cooled, broken up, and shipped to a copper smelter. The antimony skim was smelted with coke and galena to form slag and bullion portions, which were also returned to the system in the revolving cycle of treatment and retreatment that gradually extracted all of the metals contained in the smelter feed.

Softened bullion was tapped into one of four 50-ton desilverizing kettles. Removal of gold and silver from the bullion required the addition of zinc, in what was known as the Parkes process.[49] The zinc caused formation of an alloy containing gold, silver, and zinc. The alloy was skimmed from the surface of the kettle and block-formed in a mold. After several kettles had been skimmed, the blocks were melted in a kettle, and the overhead crane was used to suspend a Howard press over the kettle. While the press collected the heavy crust that formed on the kettle surface, an air cylinder closed the Howard press, squeezing out entrained lead in the crust. The alloy crust was dumped and broken up with hand tools into fragments. These were then transferred to a bin in the retort section of the Lead Refinery. Photograph ID-29-4 shows a zincing kettle during the skimming process.

The bullion that remained in the desilverizing kettles was pumped into one of three 75-ton refining furnaces. Heating the bullion charge to 1200° F. vaporized the remaining (0.6%) zinc and collected trace antimony and arsenic in a dross, which was skimmed for reprocessing in the blast furnace. The commercially pure lead was siphoned from the refining furnace through a pipe into a 200-ton merchant kettle. Lead was pumped from the kettle into the molds of the Miller casting wheel, an upright machine that dislodged solidified pigs by gravity at the end of its cycle. Each pig weighed 100 lbs. Smaller, 5-pound strings of plumber's caulking lead were hand cast, also. Photograph ID-29-5 shows pigs stacked on a cart after removal from the casting machine.

Extraction of zinc from the gold/silver crust was accomplished in tilting Faber du Faur retort furnaces. At the time of Rickard's visit in 1920, the alloy crust was removed from its bin, "drawn into a car and weighed in 1200 lb. charges."[50] This charge material was shoveled into the retorts which were then set in the eight retort furnaces. Zinc vaporized in the retorts, collecting in attached condensers. The condensed zinc was drawn off into molds and transferred back to the zincing kettle, where it was used for desilverizing the next batch of bullion.[51]

The dezinced retort metal was dumped into molds, which were used to transfer the metal to 60,000 oz. capacity cupels in the Silver Refinery, a separate building adjacent to the Lead Refinery on the west. Within the furnace that contained the cupels, lead was separated from the gold and silver bullion. The lead oxidized under heat while the surface of the bath was subjected to a flow of air. This formed a litharge, which was skimmed into small pots. As with the other process skimmings, these lead litharge buttons were returned to the blast furnace. The gold/silver metal in the cupelling furnace was then cast into ingots known as doré.

Separation of the precious metals was effected in cast iron parting tanks (or kettles) into which the ingots were placed. The silver was put in solution by the introduction of sulfuric acid into the tanks. The silver sulphate solution was discharged into lead-lined vats, and copper coated bars suspended from "corrosiron" hooks were lowered into the vats.[52] Application of steam heat brought the solution to the boiling point, at which time the silver precipitated in the presence of the copper, which went into solution as copper sulphate. The precipitated "cement" silver was "filtered, washed in boiling water, dried, and then melted in a Monarch double-chambered tilting furnace, fired by oil."[53] The molten metal was then cast in 1250 ounce ingots of .999% fine silver.

The copper sulphate solution was pumped over to the Bluestone Plant for final processing as copper sulfate crystals. In this building, which adjoined the Silver Refinery on the west, the copper sulphate solution was evaporated, dissolved again (in water), and re-crystallized onto lead strips in a lead-lined vat. The copper sulphate was sold to mills that were using selective flotation and "to the farmers, who use it for spraying."[54]

Gold was contained in the insoluble residue that remained in the parting tank. Rickard noted that it was boiled "to remove any sulphates" and "melted in a graphite crucible."[55] The refined bullion was cast into ingots.

After the completion of construction and the shakedown period of operation for the Lead Smelter, Frederick Bradley appointed Jules Labarthe as exectutive head of the operation (a move formally ratified by the directors in July, 1918).[56] He remained in San Francisco, the headquarters of Bunker Hill & Sullivan, overseeing the operations of the plant, which was superintended by Michael H. Sullivan (who had been with the company since the early construction), assisted by A.F. Beasley (like Sullivan, a veteran of Cominco's smelter at Trail, British Columbia). They were incharge of an operation that employed almost 300 people by 1920 (Smelter Staff-24; Blast Furnace- 69; D.&L. Roasters- 22; Bag House- 3; Lead Refinery- 39; Silver Refinery- 17; Sample Mill- 9; Electricians- 2; Cottrell Plant- 3; Coal Pulverizer- 1; Switching Crew- 4; Locomotive Crane- 2; Boiler Room- 3; Oilers- 1; Brickmasons- 9; Machinists- 18; Boilermakers- 15; Watchmen- 3; General Labor- 26; Carpenters- 14; Concreting- 7; Unloading- 10).[57]

The Lead Smelter contracted for ore supplies with Bradley's Alaska Juneau mine and local operations like the Hecla, Alhambra, Caledonia, Sierra Nevada, and Gold Hunter Mines (in addition to the Bunker Hill's output); their product was sold to the Robert Dollar Co. (Oriental market), Northwest Lead, F.A. Hammersmith, and L. Vogelstein Co. (Eastern U.S. market).[58]

At the time of the Smelter's 1917 commencement of operations, however, the United States was involved in the Allied cause during World War I. All of the domestic output of lead was needed for the war effort, thus the Bunker Hill Lead Smelter, along with other lead manufacturers and dealers, cooperated with the Lead Producers Committee for War Service regarding distribution of their product. Still, demand outstripped availability, causing the Committee's chairman to reiterate the need to "eliminate non-essential uses of lead in order that there may be more available for direct and indirect United States Government orders and for other work of national importance."[59] The Committee continued its controlling function until December 21, 1918, when restrictions on resale were lifted, more than a month after the War's conclusion.

Another effect of the War was the attendant labor shortage, as men were called to serve in the Armed Forces. This situation was aggravated by the influenza epidemic which ravaged the country in 1918, and which was being felt acutely by the Lead Smelter in the fall of that year. Michael Sullivan, in his telegraphed report to San Francisco of production for the ninth of November, appended these remarks to his figures: "Flu conditions still bad. Many employees off. About three deaths per day."[60]

Despite the conditions imposed by war and illness, the Bunker Hill Lead Smelter remained operational, with expansion planned for production areas like the Blast Furnace and Lead Refinery.[61] When Rickard visited the plant in 1920, he noted that the Cottrell treater, although designed to handle the fume from five roasters, was processing fume from nine roasters. Expansion of that facility was envisioned, enough to include treatment of fume from the Refinery, which was treated in the Bag House at that time.[62] Process and physical changes were to be an ongoing feature of the Lead Smelter's operating life.

E. Changes at the Lead Smelter 1924-39

With a plant as large and varied as the Bunker Hill Lead Smelter, alteration and improvement of buildings and equipment occurred with a frequency dictated by necessity. A good example of this was the work required in upgrading the Bag House and Cottrell. Frederick Bradley addressed the problem of dust recovery from the fume when he wrote to Stanly Easton in 1923, recommending the diversion of men from the electrolytic pilot plant at the North Mill "to the very pressing smelter construction program, such as bag house, etc."[63] This need was eventually met in 1924, when four more sections were added to the Bag House (giving that facility a total of seven sections), and a new Cottrell treater erected "with necessary spray chambers for the recovery of metal-bearing dust and fume."[64] Within a year, money had been appropriated for a wall around the Cottrell Plant to protect it from cold air, which was causing condensation on the outside of the brick walls, resulting in "small cracks in the brick work."[65] Earlier in 1925, money was appropriated for flues and a fan from the byproduct furnace to the Bag House, so that materials could be recovered from a fume source that was formerly wasted. Summertime temperatures increased the danger of fire in the Bag House, thus money had to be appropriated in 1926 for additional cooling flues for the byproduct furnace fume.

Improvements of this nature were made in other areas, such as the provision of a roof to extend over the lead loading track at the Refinery in 1925, the building of a new Chemical Laboratory (the old one in the Assay Office being inadequate) in 1926, and the construction of a residence for A.L. Larson, the plant engineer (also 1926). As part of the original construction, six houses had been built adjacent to the Lead Smelter. These housed the families of M.H. Sullivan, A.F. Beasley, and other salaried employees.

The interlinked nature of the Lead and Silver Refineries led to their being joined in 1927, with the perceived advantage that this would "give more room for silver and lead refinery operations."[66] In that same year, $33,000.00 was set aside for replacement of the Copper Sulphate (Bluestone) Plant, and a new lead casting wheel was purchased from St. Joe Lead Company.

Several changes had occurred during the Lead Smelter's first decade of operation, but even greater changes were anticipated following the conclusion of Bunker Hill's contractual obligation to A.S.&R., when all of the Company's concentrate output would be available for the Lead Smelter. Easton alluded to this in 1929, when he reported to shareholders that plans were being drawn up for modernizing and enlarging the Lead and Silver Refineries, including the implementation of "modern appliances for casting, handling, and loading the pig lead."[67] Increased production capacity was already present in the Blast Furnace Department, where four furnaces were in place, with only two operating. One of those two furnaces was used only on an occassional basis, as the sinter produced by the Dwight & Lloyds was more than one furnace could handle, but not enough for two until a stock had accumulated to allow blowing in a second furnace. To alleviate this situation, Bunker Hill dismantled one of the furnaces and built a furnace on the same site in 1936 that Stanly Easton declared was "believed to be the largest lead producing blast furnace in the United States."[68] It was 66 inches by 252 inches at the tuyeres, and it was based on a design that had been put successfully into practice by Cominco at their Trail, B.C. smelter.[69]

The Great Depression had a pronounced effect on the metals industry, as well as all other facets of economic life in the United States during the thirties. Undoubtedly, this affected Bunker Hill's plans for modernization of the Lead Smelter. Production was necessarily curtailed in the face of a low lead price. Survival took precedence over expansion, a situation noted by one of Frederick Bradley's consulting engineers when he replied to another engineer (with plans for a new process) that they were "more concerned with keeping alive some small part of the present installation, and could not be prevailed upon to discuss any additional capital expenditures."[70] Bunker Hill did keep their smelting investment alive, and managed to make improvements like the enlarged blast furnace. The end of this difficult period found the Company able to undertake the building of process additions contingent upon the development of the "Dry Ore Belt" of the Coeur d'Alenes, and, with World War II in the offing, to plan and construct two other plant additions for processing slag (for its zinc) and fume (for its cadmium).

F. Process Additions and Modifications at the Lead Smelter 1939-60

By 1939, the Lead Smelter used ten Dwight & Lloyd sintering machines (as opposed to the nine, with one Wedge roaster in 1920), produced all of its lead bullion in the enlarged blast furnace (with a smaller one on standby), and had altered the size and number of Lead and Silver Refinery furnaces and kettles.[71] Six 100-ton drossing kettles received the bullion from the blast furnace. They were arranged in two rows, the greater part of the dross being removed in the two head kettles, the others being used for cleaning out the remainder. Two 350-ton capacity softening furnaces were used to remove the antimony and arsenic, three 225-ton zincing kettles served to hold the bullion for skimming and pressing, and the trace zinc was removed from the bullion in two 275-ton refining kettles. Two 225-ton capacity merchant kettles held the commercially pure lead prior to pig formation on one of the two casting wheels. One of the casting wheels was used for production of hard lead pigs. In the Silver Refinery, two liquating kettles had been added to that department, and the cupels had been changed to Rhodes 100,000 oz. capacity units.

Selective separation of gold from silver was part of the plant practice in 1939. In his Engineering & Mining Journal article in August of that year, A. F. Beasley noted that "monthly silver output [was] increased by 1,000,000 oz." during the summer months, when the Lead Smelter received high tonnages of concentrates from the Yukon Territory.[72] Under bulk separation, this would have required a large increase in parting tank and Bluestone Plant equipment to handle the seasonal load, with the excess capacity left idle during the rest of the year. Liquation of the silver in the zincing kettle dross would reduce the weight of the material to be processed by about half, but oxides in the dross would interfere with efficient liquation. The solution lay in degolding the softened bullion first, thus removing the oxides in question.[73] As a result, the gold was skimmed and pressed in the center zincing kettle. When assays indicated that nearly all of the gold had been removed, the bullion was desilverized in the zincing kettles to either side of the kettle used for degolding. This process modification made possible the subsequent material weight reduction of silver dross liquation.

The two 18 in. diameter by 60 in. deep liquating kettles that had been added to the Silver Refinery each had upper and lower sections that were bolted together through flanges. A ½ in. water line between the sections formed a seal. During operation, desilverized lead was admitted to fill the lower section, and a charge of silver dross was added to fill the kettle. Heat was applied to the upper section, causing excess lead in the dross to liquate and gravity separate from the silver. Molten zinc-silver alloy was ladled from the upper section, while liquated lead discharged through a 2 in. diameter pipe siphon on the lower section. Nearly half of the "dross feed weight [was] liquated as a low-silver bullion, which [was] returned to the desilverizing kettle."[74] The remaining alloy crust, higher in silver values, was processed as before in the retorts, cupels, and Monarch refining furnace. The pressed gold dross was not liquated, but it still required treatment in the parting tanks, after retorting and cupellation, to separate the approximately 12% silver in the doré from its gold counterpart.

Development of the Sunshine Mine and other properties in the "Dry Ore Belt" (also known as the Silver Belt) during the thirties brought ore of a different character into the Lead Smelter's feed supply. This concentrate was rich in silver, but it also contained quantities of copper, arsenic, antimony, and bismuth that required removal before introduction into the Lead Smelter's established processing system. To pre-treat this ore, Bunker Hill built the Dry Ore Plant in 1939, at the western edge of the complex, above Charles Sweeny's old mill on Sweeney Point. The Dry Ore Plant (or D.O.P., as it was commonly known) contained a Herreshoff roaster for converting the sulfur in the ore into SO2, which was carried in the fume by a flue to the Bag House. As with the other gaseous products at the Smelter, particulate matter was captured for reprocessing, and the SO2 vented out the Lead Smelter's stack. The concentrate was rabbled down through the roaster's seven hearths, and that product was subjected to further treatment in the Lead Refinery's reverberatory byproduct furnace. The bullion that came out of that was reheated in the cupelling furnace to produce a silver dore (which was refined in the Monarch tilting furnace) and a litharge. If the litharge was high in bismuth, it was stored for useage in producing "common" lead, otherwise it was returned to the reverberatory.[75] Concurrent with the building of the D.O.P., the Sweeney Mill was converted into an electrolytic Antimony Plant for recovery of metallic antimony from the "dry" ore.

Production of antimony was aided by the construction of the Electric Furnace Building, adjoining the D.O.P., in 1941. It contained an electrical induction furnace with three in-line carbon electrodes. This unit replaced the Herreshoff roaster. Concentrates were charged to the furnace, which was supplied with a mix of coke, caustic soda, and spray-dried salts (from a leach residue obtained later in the process). The molten material that came from the furnace was drawn off into rolling pots, and the fume treated as before. The buttons that solidified in the pots were emptied onto a barred covering (known as a grizzly) over a jaw crusher. They were crushed and conveyed to the top floor of the D.O.P., where shaker tables separated out the silver-bearing material for the Refinery, and the antimonial product was conducted into a leach tank. The antimony was dissolved in a sodium hydroxide/sodium sulfide solution and gravity fed to the Antimony Plant's cell room, where it was electrolytically plated onto cathodes. The antimony was stripped from the cathodes, melted in a furnace, and cast into square ingots for marketing as Star brand antimony.[76] Production of antimony continued at these facilities until 1946, when it was discontinued, and the Sweeny Mill torn down.[77]

Erection of the Slag Fuming Plant (to the east of the Blast Furnace Building) in 1942 gave the Lead Smelter a zinc recovery capability that it hadn't possessed before. Beginning in 1943, the slag that was periodically drawn off the Blast Furnace was conveyed by crane into this plant, where zinc was recovered in an oxide form. The former slag dump was also broken up and reworked for its zinc values in this new plant. Slag was charged into a furnace, where the combustion of pulverized coal vaporized the zinc into the air above the bath, forming zinc oxide. Heat from the ZnO fume provided steam generation via a waste heat boiler, following which the fume was fed by a flue through a series of "hairpin" cooling towers. The oxide material was finally captured in an adjacent bag house. It was collected for sale and shipment to manufacturers of paint and automobile tires. Better than 90% of the zinc in the slag was recovered through the operations of this plant.[78] The remaining slag component was drawn off into a granulating pit, where high-pressure water jets fractured it into a granulated ferro-silicon slag. For many years after the inauguration of this new procedure, the granular slag was utilized by city and county road departments as a traction sand in the winter. It also saw use as a Proportioning Plant feed (diluent) in the Ore Preparation Plant that was put into operation after 1953. Photograph ID-29-6 shows the Slag Fuming Plant under construction in 1942.

Wartime provided an improved market for cadmium as well as lead and zinc, thus Bunker Hill planned and built the Cadmium Plant at the Lead Smelter in 1945. Bag House dust contained the source of the plant's feed, but this material had to be treated in a reverberatory furnace to produce an enriched cadmium fume, which was collected in a separate baghouse until a sufficient quantity of dust for processing had accumulated (the furnace byproduct being returned to the Blast Furnace). The Electric Furnace replaced the reverberatory for fume production after 1959.

The cadmium dust was stored in a tank, until a 7000 lb. charge had been built up. The charge was conveyed into a ball mill, water was added, and it was ground up with steel balls. When grinding was complete, the material was discharged into a lead-lined tank. Sulfuric acid was added, and the solution was pumped through a Shriver plate-and-frame press to capture impurities. The pregnant solution that came out of the press was pumped into a holding tank. Four to five filterings of solution charges filled the tank, and potassium permanganate was added to aid oxidation of the cadmium. The solution was pumped into another lead-lined tank, where the cadmium was precipitated out of solution with zinc dust. Separation of the cadmium (which assumed a sponge form) from sulfuric acid and water was achieved in a succeeding filter tank. A zinc sulfate byproduct was generated along with the cadmium sponge. After removal of the sponge for further processing, the zinc sulfate was sold to mining companies for use in their milling processes.[79]

Initially, the cadmium sponge was refined in retorts at the Lead Refinery to produce cadmium metal, but in 1957 Bunker Hill began shipping the sponge to their Zinc Plant, where it was mixedwith the sponge produced at the Cadmium Plant there. This elimination of "the former high cost retort method of refining" was made possible by the 1955 dissolution of the Sullivan Mining Co. (the operating entity of the Zinc Plant), which joined the Zinc Plant and Lead Smelter under the single ownership of the Bunker Hill Company.[80] Photograph ID-29-7 shows the Cadmium Plant as it appeared in January, 1993. The building was situated to the west of the Smelter's brick flue and above the Electric Furnace/D.O.P. buildings.

The Slag Fuming and Cadmium Plant additions to the Lead Smelter helped to offset production losses tied to the shortage of labor in World War II, a shortage that was partially made up by the employment of women and furloughed soldiers. With the end of the war, Bunker Hill resumed full production at the Lead Smelter. A brief strike interrupted operations from August 31 to November 14, 1949 (the first strike against Bunker Hill since the violent work stoppage in 1899), but the company proceeded with planning for the next important modification of plant processes, an ore preparation facility. Engineering studies for the Ore Preparation Plant were underway by 1951, and plant construction took place in 1951-52, with the facility becoming operational in 1953. Establishment of better controls in preparing a concentrate for sintering was the idea behind the O.P.P., as the nature of the smelting product had changed since the beginning of operations in 1917.

During the 1916 planning for the Lead Smelter, Stanly Easton had written to Jules Labarthe about the East Helena, Montana smelter's practice of adding lime and other fluxes to the concentrate before sintering. He noted that this was beneficial to the operation of the smelter stacks, and that "smelter officials declare this new practice is the biggest thing which has happened in lead smelting in their experience."[81] This practice was incorporated into the original charge preparation system at the Lead Smelter. Concentrates were sintered with some fluxing material, and then stored in the charge bins at the western end of the smelting complex. The sinter was then combined with additional fluxes for blast furnace reduction. The blast furnaces functioned efficiently under this simple system.

The lead-rich ore in the charge came largely from gravity (jig) mills, which produced relatively little wet fines (which affected the porosity of the sinter), compared to that produced by flotation milling. However, flotation was a more efficient extractor of metals, especially in the selective separation of lead and zinc into concentrate form. After 1938, more of these fine concentrates were being received at the Smelter (in addition to the fine leach residue from the Zinc Plant). A higher temperature in the blast furnace was needed for this type of feed. This "required a higher smelting column and the higher column, in turn, rendered the blast furnace less receptive to improperly prepared feed."[82]

Although World War II delayed resolution of this problem, laboratory experiments and pilot plantwork performed during 1948-50 indicated that improvements in the presintering phase of the Lead Smelter's flowsheet would lead to satisfactory blast furnace performance. The key components of this revised presintering system were: "1) An all-weather system; 2) Facilities for crushing all oversize materials to less than one quarter inch; 3) Enough bins- designed to permit positive flow- to maintain adequate segregation of charge ingredients; 4) Provisions to obtain presinter analysis of the composite charge and a means of correcting indicated deficiencies; 5) Adequate charge blending and pelletizing facilities."[83]

The Ore Preparation Plant encompassed all of these requirements. It was built on the eastern verge of the Lead Smelter, the four main components of the facility being a Crushing Plant, Charge Storage and Proportion Section, Bedding Plant, and Pelletizing Plant.

The Crushing Plant was designed for "1) crushing and grinding to less than one-quarter inch, minor volumes of crude ores and major tonnages of charge diluents, fluxes, and circulating byproducts; 2) intermediate reduction and sizing of both finished byproducts and pallet dressing."[84] It utilized a Traylor jaw crusher to achieve an initial reduction of material to less than two-and-a-half inches. The reduced material was then discharged to a cone crusher, which reduced the feed to less than three-quarters of an inch. From this machine, material was fed to one of three pieces of process equipment: minus three-quarter inch sinter went to a deck screen with one-quarter inch openings; material with excess moisture was conveyed to a rotary dryer; and the bulk of the feed fed into a bin to await final reduction in a 9 by 12 foot Allis-Chalmers rod mill. Dust was captured in a baghouse containing woolen bags.

The Ore Preparation Plant received the output of the Crushing Plant, along with fine concentrates, granulated slag, and leach residue from the Zinc Plant. These components were all separately stored. From these bins, materials were combined into a properly proportioned composite that was run through an impactor to break up lumps and blend the ingredients. Sampling was conducted as the material was conveyed into the Bedding Plant.

Four 925-ton bedding piles formed the basis of the Bedding Plant's operating cycle. While one pile was being formed, a second pile was assayed, a third pile underwent metallurgical correction, if required (with additional Proportioning Section material), and the fourth pile was harrowed by a Stearns-Roger reclaimer (at the rate of 175-200 tons per hour) onto a conveyor leading to the Pelletizing Plant surge bin.[85]

Pelletizing the charge gave the sinter feed the desired physical characteristics for complete sintering. After treatment with water in a pug mill, the feed was fed into a rotary pelletizer. Pellets were hardened in a rotary dryer before being belt-conveyed to the Sintering Plant. The operations of the O.P.P. components resulted in "a marked increase in smelting capacity" due to the gain in sinter feed consistency.[86]

Modernization of equipment used in Lead Refinery processes was a significant feature of the decade following 1950. Experiments with a continuous softening furnace in 1949 (based on a model developed at Port Pirie, Australia) proved successful, and two of these units replaced the old, batch-style furnaces.[87] These furnaces were smaller than the 350-ton capacity furnaces that had formerly been in operation, but their continuous output and ease of operation enhanced the production of the Refinery. The batch system had changed from the initial method of rabbling lead antimonate from a slightly cooled furnace. To augment the oxidation of the antimony, blowpipes were inserted into the furnace bath to agitate the bullion. The ends of the iron pipes were prevented from burning off at the hot bath line by the use of a movable filler rod inside the pipe, which diffused the heat through the pipe's length. To avoid having the air jet weaken the furnace walls, the pipe was aerated where it entered the bath and its end was plugged.[88] While the softening furnace was operating, antimony ran off through a discharge spout in a thin stream.

Continuous softening also produced a stream of antimony.

Drossed bullion was pumped from the drossing kettles into the reverberatory furnace at a temperature of 760° F. The lead bath in the 15 ft. by 5 ft. hearth of the furnace was kept at an average 12 inch depth.[89] Air blowers within the furnace ran from its arch down into the bath. External heat was applied, when required, to raise the temperature of the bath. The oxidation of the antimony and arsenic in the bullion generated heat sufficient enough to raise the temperature of the bath to 1400° F. At that temperature, softened bullion exited through an overflow notch in the furnace's discharge end, while antimonial slag overflowed "through a notch at the flue end of the furnace."[90] The slag was captured in pots and transferred for further processing in the byproduct reverberatory furnace.

Zinc removal after de-silverizing was facilitated with the usage of a vacuum de-zincing bell, beginning in 1955. This device had a water jacket over the bell portion and a cast-iron skirt below that. By means of a crane, the skirt was submerged in the kettle, and a counter-clockwise agitation of the bullion begun. Zinc would vaporize from the bath and condense onto the cold surface of the bell. After the bell had been raised, sampling would indicate if all of the zinc had been removed.[91]

Replacement of one of the St. Joe casting wheels with a straight-line casting machine (designed by Bunker Hill engineer Les Vance) in 1956 resulted in a 500% increase in output capacity per man shift.[92] One of the horizontally mounted St. Joe casting wheels was kept in service for hard lead runs, and it was modified for production of 1-ton blocks.[93]

Process alterations occurred in other areas during this time. In 1955, Bunker Hill began using the Electric Furnace for production of hard lead utilizing accumulated antimony slag. This relieved the Blast Furnace Department of having to shut down a furnace and clean out the flues in preparation for this blast furnace campaign. Use of the Electric Furnace for antimonial lead runs represented a great savings in time and effort for the Blast Furnace Plant operators.[94]

Pulverized coal and fuel oil had been used as the primary means of firing the Dwight & Lloyd sintering machines, along with other pyrometallurgical equipment at the Lead Smelter, from the start of operations in 1917. A switch to natural gas as the fuel source began in 1957, and by early 1958, plant-wide conversion had been completed.[95]

Of future significance to the sintering process at the Lead Smelter was a 1958 experiment involving one of the Dwight & Lloyd sintering machines.[96] These normally operated with a downdraft air supply. Conversion of the D.&L. in the pilot work to an updraft configuration in 1958 was meant to investigate generation of a gas stream that contained a higher percentage of sulfur dioxide. An SO_2-rich gas stream was needed for the production of sulfuric acid, a salable commodity that Bunker Hill had begun producing at the Zinc Plant's Acid Plant in 1954. The successful results of this experiment provided Bunker Hill with data that would be useful in the eventual construction of the Lead Smelter's Acid Plant in 1970.

G. The Closing Era of the Lead Smelter 1960-81

At the beginning of this era, Bunker Hill endured a protracted and bitter strike during most of 1960. Its long-time leader and president emeritus, Stanly Easton, died at the age of eighty-eight the following year. His passing severed one of the last remaining links with the Lead Smelter's origins.

These final decades of operation for the Bunker Hill Lead Smelter saw continuing physical and process modifications, as the Company sought to remain competitive in a changing metals industry. One of these changes was tied to the success or failure of a method for the pressure leaching of copper-bearing materials. Other changes revolved around the updraft sintering experiment of the late-fifties. A change of particular significance to the Lead Smelter occurred in 1968, when Gulf Resources staged a successful takeover, claiming The Bunker Hill Company as a wholly owned subsidiary. In the seventies, the operations of the Lead Smelter that Gulf controlled were to come under the increasing scrutiny of those responsible for administering the growing body of environmental regulations, and, as a result, much money and effort would be expended complying with clean-air and water laws. During the last years of the Lead Smelter's operations, a remarkably high silver price would spur development of electrolytic silver refining.

Starting in 1964, Bunker Hill investigated the use of pressure leaching as a means of separating other metal constituents from the lead contained in the Smelter's feed. The desired outcome of this would be recovery of copper, arsenic, and antimony prior to the smelting process, where these metals hindered efficient lead smelting. Experiments with this method had been performed on a small scale by Sherrit-Gordon, Ltd., in Canada. Bunker Hill obtained second-hand equipment from National Lead Co., and, with consulting help from Sherrit-Gordon, implemented the new process on a pilot plant basis.[97]

High copper/lead concentrates, copper-bearing byproducts, and some crude ores were introduced into a repulping tank containing a weak sulfuric acid solution. From there the pulp was pumped into the autoclave, a 6 foot diameter by 18 foot long pressure vessel housed in a building (since removed) to the west of the Lead Smelter's main Bag House. High pressure steam, provided by a Besseler boiler, in conjunction with air pressure (supplied by two Ingersoll-Rand P.R.E. compressors) and the approximately 425° F. temperature attained during the autoclave reactions formed the leach environment.[98] Leaching was performed "under pressure rather than at atmospheric pressure because (1) pressure leaching in an autoclave allow[ed] a higher ratio of leaching reagents- oxygen and steam- than may be obtained in atmospheric leaching; and (2) higher operating temperatures [were] obtained from the exothermic heat of rapid leaching (sulfation), and this reduces leaching time."[99]

From this first step of oxidation, the leached slurry was discharged to a pressure letdown chamber, while vapor from the process was vented to a pressure letdown flash chamber (prior to collecting in a sump for pumping into a process water storage tank. The leach slurry underwent a second step of separation into liquid and solid components in thickener tanks.

The final step in this process for the leach residue from these tanks was reduction of moisture content on a drum filter. The residue contained "45-60% lead, depending upon the autoclave feed composition," and it still held silver and gold values.[100] At this point, it was ready for introduction into the Smelter's established processes.

Solution that had been freed of its residue load was discharged to a storage tank, where it was held until its final metals recovery step, when copper was to be extracted "by precipitation (cementation) or by electrolytical methods."[101]

At the pressures required (700-900 psig) for operation of the autoclave, serious problems resulted in maintenance of the pressure "letdown" systems components. An inability to resolve the problems resulted in abandonment of the pilot plant project in 1966.[102]

Bunker Hill metallurgists investigated oxygen enrichment as a means of improving blast furnace performance in 1966. The successful outcome of this experiment established oxygen enrichment as a feature of the Blast Furnace operations from that time until the Lead Smelter's closure in 1981. The Airco Company installed a plant in 1975 at the Smelter (located south of the main reservoir) for the manufacture of oxygen used in this system. This plant operated until 1981, when it was removed by Airco.

The updraft sintering pilot plant work conducted at the Smelter in 1958 laid the groundwork for two process modifications that were completed and running by 1970. One of the pilot plant experiment's objectives was the determination of "what physical dimensions would be needed to build one big new sintering machine to replace the 10 small machines" then in use.[103] Another objective was to determine if the gas stream from updraft sintering would carry a strong enough concentration of SO_2 for the production of sulfuric acid (H_2SO_4). The results of this experiment led to the installation of the Lurgi sintering machine, (along with the building of the Sinter Sizing Building and Lurgi Baghouse), and it demonstrated that the gas from updraft sintering would be enriched enough to supply an Acid Plant with byproduct gas for H_2SO_4 production.

The Sintering Plant underwent marked change. One German-manufactured unit, the Lurgi sintering machine produced all of the sinter utilized by the Blast Furnace. The Lurgi was 8 ft. (2.5 m) wide and 122 ft. (37.2 m) long, with a 753 sq. ft. (70 m^2) updraft area. It was part of a new facility, built adjacent to the

Pelletizing Plant. As with the former sintering system, a series of pallets in a continuous stream formed the traveling sinter machine bed. The pallets received a uniform 3-4 inch depth of sinter feed pellets delivered by the ignition layer conveyor at the feed end of the sinter machine. The ignition layer traveled under a gas-fired muffle, which supplied downdraft ignition to the Pellet Plant charge. As the ignition layer left the muffle, the Lurgi feed conveyor deposited a 10-11 in. deep, uniform layer of sinter feed pellets onto the ignited layer. Blowers and ducts along the length of the sintering machine supplied an updraft of air through the bed, which resulted in ignition and combustion of the sulfur throughout the bed depth. This combustion was largely completed in the first 60% of the pallet's travel.[104] It produced the "strong gas" (approximately 7% SO_2), which was first directed to a gas cooling chamber, following which dust in the fume was captured in the Lurgi Baghouse. The gas stream was then sent to the Acid Plant for conversion to H_2SO_4.

The pallet charge cooled during the last third of its travel, but residual combustion produced a weak gas, which was collected and directed to the main Bag House. At the discharge point, the pallets were relieved of their sinter by gravity as they turned on the head sprocket and began their journey back to the feed end of the sinter machine. The sinter that discharged was fractured by a rotating sinter breaker, discharging through a barred grizzly. The broken sinter masses fed into the discharge conveyor.

The sinter was conveyed into the Sinter Sizing Building, adjacent to the Lurgi sintering machine on the west. Here, it passed through crushers, grizzlies, and screens on its way to becoming properly sized Blast Furnace feed. Roughly 60% of the material fit Blast Furnace requirements, and it was conveyed to Sinter Storage. The 40% that was undersize was cooled, roll-crushed, and returned to either the Pelletizing Plant or to the Ore Preparation Plant for production of sinter machine feed.[105]

The former Sintering Plant had been located to the north of the main Bag House. All ten of the Dwight and Lloyd sintering machines were torn out, and the structure that housed them was removed upon completion and successful operation of the Lurgi sintering machine.

The output from the Lurgi facility was conveyed to the Sinter Storage/Blast Furnace Feed System that was built in 1966. This was located to the south of the Blast Furnaces and west of the Lurgi Baghouse. Stored sinter was discharged by a variable speed belt feed system which controlled the sinter charge rate to the Blast Furnace feed conveyors. Coke storage utilized a similar system to control the coke feed rate to the Blast Furnace. In this manner, a properly weighed ratio of sinter to coke was achieved. The coke/sinter charge was fed to the operating Blast Furnace's charge bin by a transfer conveyor. Chutes led from the bin to a feed conveyor, which supplied two shuttle conveyors that continuously laid a uniform bed of charge material the full length of each side of the Blast Furnace feed column. This completed the production and delivery of sinter to the Blast Furnaces in the system employed at the Bunker Hill Lead Smelter from 1970 until the end of production in 1981.

Bunker Hill had been marketing saleable byproduct sulfuric acid made by the Bunker Hill Zinc Plant's Acid Plant since 1954 (with a second Acid Plant coming into production in 1967). In the late sixties, manufacture of H_2SO_4 took on a new dimension- as a means of meeting the clean air standards that had been enacted. SO_2 emissions had long had an effect on vegetation in the Kellogg area. In 1950, a Bunker Hill plant pathologist had noted that "sulphur dioxide when present in the air is absorbed by the stomata of the plant along with the air. When this takes place and the SO_2 comes in contact with the moisture of the leaf, it is changed to SO_3 and burning results."[106] SO_2, when enriched to a sufficient strength, could be used in the manufacture of sulfuric acid, relieving the area's environment of the effects of sulfur dioxide gas.

The strong gas stream that came from the Lurgi sintering machine was processed in the Lead Smelter's Acid Plant, which was completed and operating in 1970. The Monsanto Acid Plant was installed by the Leonard Construction Company, and it was situated to the south of the main Bag House. The old Cottrell treater was no longer used for capturing dust in the fume after the Acid Plant became operational, and it was demolished in 1973. The Monsanto designed plant was a standard facility for the manufacture of H_2SO_4, identical to those installed at the Zinc Plant in 1954 and 1967.

Gas from the sintering process was relieved of dust particles in the Lurgi Baghouse. The Acid Plant's main blower drew the fume from there into the the gas cooling tower/scrubber, where counter-current water sprays cooled the gas and removed part of the remaining entrained solids. Cleaned gas from the scrubber was drawn into two mist precipitators, which relieved the gas of acid mist and minute amounts of metallic dust through electrostatic precipitaion. At that point, cleaned gas was drawn by suction through a drying tower, within which a counter-current flow of 93% H_2SO_4 was utilized for absorption of the remaining water in the gas stream.

The Allis-Chalmers type D-24JR CW main blower exhausted gas from the drying tower into a knock-out tower where more entrained material was scrubbed from the gas.[107] Purified gas was driven by the blower through a series of three heat exchangers. The heat exchangers were used to control the SO_2 gas temperature to the optimum gas conversion temperature and to minimize variation in the gas temperature during conversion of the SO_2 into SO_3 in the Monsanto "3 Pass" converter.[108] The chemical reaction that took place was accelerated by passing through vanadium pentoxide (V_2O_5) catalyst layers within the converter. Gas exhausted from the heat exchangers and entered the top layer of the catalyst in the converter, returning to one of the heat exhangers after the first pass. Successive passes through the catalyst layers in the converter were followed by a return to a heat exchanger. Each time, more of the SO_2 was converted into SO_3. After the third pass, the chemical reaction was complete, and the gas was ready for cooling and absorption into sulfuric acid.

The absorbing tower was linked to the drying tower, supplying it with the 93% H_2SO_4 needed for absorbing water from the incoming gas, at the same time that it received a cross-flow of diluted acid from the drying tower. The diluted acid was used to keep the acid strength in balance as SO_3 was absorbed into H_2SO_4. Acid generated by this plant was pumped by two Durco Mark II product acid pumps to the top of and along the ridge behind the Lead Smelter and then let down into tanks in the Acid Storage area below the Zinc Plant in Government Gulch.[109]

Environmental considerations continued to affect planning at the Lead Smelter in the seventies. An Effluent Treatment Facility was put into operation at the Smelter in 1970. The facility was located in the area between the Smelter Dry and the O.P.P. and adjacent to the Crushing Plant. Water used in conveying byproduct slag to the O.P.P., Crushing Plant runoff, Lurgi sinter machine fume (collected in the strong gas cooling chamber), and weak acid runoff from the Smelter Acid plant were cycled through this facility's process equipment. The effluent was collected in sumps located in the above listed plant areas and pumped to an agitated holding tank. Effluent from the holding tank entered a reaction tank (also equipped with an agitator), where a controlled flow of lime slurry was added to neutralize acid and precipitate metal ions. Following lime treatment, the slurry discharged to a thickener tank. The sludge from the thickener tank was pumped to a drum filter for dewatering; the resultant filter cake was returned through the impactor to the Bedding Plant circuit. Filter solution was returned to the thickener, where it joined the thickener overflow solution and was pumped to the slag granulating reservoir.

In subsequent years, a number of wet scrubbers were utilized to control dust emissions in the sinter sizing and cooling processes. Effluents from these dust collection systems were also directed to the Smelter Effluent Treatment Plant.

In 1973, the U. S. Bureau of Mines built a pilot plant facility between the Main Baghouse and the Smelter's Acid Plant. They were investigating the use of a citrate process in converting exhaust gas SO_2 into elemental sulfur. The Bureau was successful in producing elemental sulfur, but the pilot plant was abandoned after a short operating period.

Seeking to disperse the plant's exhaust gases over a wider area (thus diffusing them), Bunker Hill built a new High Velocity Flue system, connected to a 715 foot tall stack. Upon completion and successful operation of the new High Velocity Flue/Tall Stack project in 1977, use of the old Brick Flue (in operation since 1917, and which had connected the Blast Furnace exhaust gases to the main Bag House), the old Bag House exhaust fans, the wagon box flue, and the 200 ft. Stack (in operation since 1954, having replaced the original 1917 stack) were all abandoned. By the seventies, this original flue system required constant maintenance as breaks in its expanse developed. The steel High Velocity Flue which replaced it arced over the complex from the Blast Furnace to the Bag House inlet flue. From the Bag House outlet flue it connected to the 715 ft. Stack. Push fans sent the fume into the Bag House, and pull fans drew the gases out of the Bag House and discharged them out the tall Stack.

The last process addition to the Lead Smelter was the Electrolytic Silver Refinery, which was put into operation in 1978.[110] The ending years of that decade saw the prices of gold and silver reach new highs. In response to this, Bunker Hill sought better extraction of these metals in pure form through the use of an electrolytic silver recovery system.

Gold/Silver dore´ bars cast from metal that had been treated in the cupelling furnace were placed in Balbach-Thum cells containing an electrolyte bath made up of nitric acid (HNO_3) and silver (80 grams per liter). The anodes were four 30-lb. bars of dore´ which were placed in a FRP anode basket that was completely lined with a synthetic filter cloth; the basket was supported by the sides of the FRP cell box, with the bottom half of the basket immersed in the electrolyte. A dore´ "candlestick" was placed on top of the group of silver anodes, and the positive pole of the electrical circuit was fastened to the top of the candlestick. The cathode was a stainless steel plate which covered the bottom of the cell and then sloped up and over the free end of the cell box. The negative terminal for the power circuit attached to the cathode outside of the cell. A direct current passed through the electrolytic cells, resulting in the deposition of silver crystals (dendrites) on the surface of the cathode. A small addition of scrap copper (50 g/L) was used to generate uniform silver crystal formation.[111]

Periodically, a silver crystal collection cart was positioned at the free end of the cell, and the pure silver crystals were raked into the cart. The bottom of the cart was formed by a filter media which allowed entrained electrolyte (and subsequent silver crystal cleaning wash water) to be collected for return to the process system. A small portion of the electrolytic silver crystals was used to remake cell electrolyte, while the majority was melted and cast in 1000 oz. ingots as 99.99% silver- the final marketed product.[112]

The anode sludge, which was deposited on the anode basket filter cloth as the anodes went into solution, contained the gold residue from the dore´ anode. The filter cloth that held the gold residue was transferred to a wash table, where the residue was washed and vacuum dried. The gold bearing residue was then ready for melting in a kettle on a heated plate. An addition of HNO_3 was used to extract any residual silver in the residue, and the mud was again washed and vacuum dried. The purified gold from this process was melted in an electric induction furnace and cast into anodes. These were placed in a small electrolytic cell containing a hydrochloric acid/gold electrolyte. Application of direct current to the cell effected the plating of pure gold onto gold starter sheets (cathodes). Upon completion of the gold deposition, the cathodes were melted in a gas-fired melting pot and cast into ingots. The facility produced an estimated 400-500 ounces of 99.9% pure gold per week during its years of operation, from 1978-81.[113]

The silver wash waters were stripped of their silver content by the addition of a salt solution, which caused formation of a silver chloride. After filtering, the silver chloride was melted in a refining furnace, to burn off the chloride, and the silver was used in making up a subsequent batch of dore´ anodes. The copper that was in the filtrate was recovered in a tank containing iron shavings. Cement copper was precipitated upon reaction with the iron in the tank.

The initial Electrolytic Silver Refinery had a total of 96 Balbach-Thum cells. In 1980, a 50% expansion was made with the addition of 48 cells. Concurrently, a cement block building addition was made on the north side of the refinery which housed a new melting (induction furnaces), casting, and shipping facility. This replaced the melting and casting facility which had been installed in 1978.

The Bunker Hill Lead Smelter came to the end of its operating life in 1981. The number of local ore suppliers had declined in the years since World War II, leaving the Company dependent on outside sources, many overseas. Third world competitors in the smelting trade had the edge in obtaining these ores, with their lower labor costs. That, and the financial burden of environmental expenditures, cut severely into the Lead Smelter's operating profits. Those profits were further undercut by the tremendous decline in the market prices for base metals in the late-seventies (followed by a decline in precious metals prices at the end of the "Silver Boom" in the eighties). By late August, 1981, Gulf Resources had arrived at a decision to close the plant, along with Bunker Hill's other local operations. Production, which had peaked at 305 tons of metallic lead per day, ceased in early 1982. A subsequent attempt by a new company, Bunker Limited Partnership, to revive the operations failed, and the Lead Smelter fell into decline, much of its equipment sold and salvaged. As part of the twenty-one square mile Superfund site that encompasses it, the plant is subject to eventual demolition. Photograph ID-29-8 shows the combined Lead and Silver Refineries as they appeared in early 1993, eleven years after closure.

H. The Bunker Hill Lead Smelter- Its Personnel and Its Significance to American Industrial History

The Lead Smelter that the Bunker Hill & Sullivan Mining & Concentrating Company built on the ridge above Sweeny Point in 1916-17 brought a new element into the Coeur d'Alenes. Up to that time, the district had been a producer of raw and concentrated ores which were shipped off to distant smelters for refining. Bradley's and Easton's desire to make Bunker Hill independent of the American Smelting & Refining Company for their processing needs, caused them to take the important step of establishing their own plant for production of finished lead, hard lead, and byproduct gold and silver. The Lead Smelter became an extremely important industrial presence in the economic life of the Coeur d'Alene Mining District (and the overall Eastern Washington-Northern Idaho area), employing one of the largest workforces of any of the local mining-related operations then in production. It was part of a smelting industry that was marked by "the increased use of capital, the creation of urbanized labor forces, the quest for technological advance, the rise of professional managers, the drive for lower costs, and the rationalization of all aspects of production," all characteristics of the development of American Industry during this era.[114]

It was of critical importance for Bunker Hill to recruit experienced smeltermen in order for their plant to succeed. They began by hiring Michael H. Sullivan to superintend the operations of the Lead Smelter in 1917. Sullivan had several years experience at the Cominco smelter at Trail, British Columbia. His assistant, A. F. Beasley also came from Trail, along with Silver Refinery foreman Archie Donaldson. Stanly Easton found Sullivan useful in helping to recruit smelter veterans, advising Jules Labarthe that he had "asked Mr. Sullivan to write to Mr. Donaldson, at Trail, for his best terms and endeavor to early make a definite arrangement with him. In my judgement it is better to secure a competent man we know than to get some stranger whose employment would be of a temporary nature."[115] The Trail smelter was also the source of employees like Blast Furnace foreman Sid Butler and Blast Furnace shift boss Dan Marchi.[116]

Other members of the Lead Smelter's early staff were: Herman Witteborg (Lead Refinery), J. B. Schuettenhelm (Cottrell, "roaster charges, and testing department"), P. C. Feddersen (chemist), and G. C. Gage (Office manager).[117] They were assisted in operating the Lead Smelter by men like Barney Holgan and Steve Trička (Blast Furnace shift bosses), Duncan Cameron (Mechanical Maintenance foreman), Gus Hornfelt (Yard Crew foreman), Cliff Ehlers (Pipe Shop foreman), James MoKay (Carpenter Shop foreman), Harry Eustice (Electrical Crew foreman), Vito Rubino (Track Crew foreman), and Jack Meehan (Bricklayer foreman).[118]

Throughout the years of Smelter operation, these, and other supervisory positions, were filled by knowledgable and competent men in the smelter operating and maintenance field. Many of these men learned their skills at the Smelter and subsequently advanced to supervisory positions.

Sullivan continued as Lead Smelter Superintendent until his death as the result of injuries sustained in a February, 1928 automobile accident near Wallace, Idaho.[119] A. F. Beasley succeeded Sullivan as Lead Smelter Superintendent, continuing in that post until his death in 1940. He was followed as Superintendent by P. C. Feddersen, Harold E. Lee, George W. Dunn, Donald Ingvoldstad, A. F. Kroll, Glen Blickensderfer, Douglas Baker, Ronald Johnson, Kenneth Clark, Ralph Gilges, and Kent Hudson.[120]

Several of the men who held the Smelter Superintendent's position spent a portion of their careers in the Lead Smelter's Research Laboratory. Feddersen, Lee, Ingvoldstad, Kroll and Clark all contributed to the research efforts that furthered plant productivity. They were colleagues of Bunker Hill research metallurgists like J. W. Johnson, Emil Fattu, and Kenneth Kirkpatrick.[121]

On May 11, 1963, the Lead Smelter held its first 20-Year Club meeting, honoring those employees with long service at the plant.[122] The inaugural meeting was the result of planning by a committee chaired by Kenneth Kirkpatrick, who also served as the first president of the Lead Smelter 20-Year Club. With the organization of this club, all Bunker Hill operations had 20-year clubs. Their meetings continue to be held on an annual basis, now open to all former Lead Smelter workers.

When work ceased at the Lead Smelter in late-1981, it was idled along with the other Kellogg operations of The Bunker Hill Company- the Bunker Hill Mine, Zinc Plant, and Phosphoric Acid/Fertilizer Plant. These operations, together with the various supporting facilities and offices, employed nearly 2,100 people when the decision to close the plants was reached. The Bunker Hill Lead Smelter, the second oldest Company facility, had been in operation for more than sixty-four years. Together with the Bunker Hill Mine, it had given a definable stamp to the City of Kellogg, an identity formerly proclaimed by the Kellogg Evening News masthead: "Smelter City Of The Coeur d'Alenes- World's Largest Lead-Silver Mine."[123]

I. Bunker Hill Lead Smelter Building Structural Information- Principal Production and Support Facilities (Refer to Fig. 1).[124]

1.) <u>Main Office</u>: Built at unknown date (wood frame, brick clad); 7,772 sq. ft.

    This structure served as the general office for the Lead Smelter.

2.) Dry House: Estimated built 1925 (wood frame, transite clad); 7,677 sq. ft.

This was the change house facility for Lead Smelter workers.

5.) Lead Storage Shed: Estimated built 1917 (wood frame); 10,292 sq. ft.

This shed supplied dry storage for refined lead.

6.) Bonnot Coal Pulverizer Building: Built 1917 (wood and steel frame, brick clad); 7,257 sq. ft.

Bonnot coal pulverizing equipment was housed in this building, which later served as a storage facility.

8.) Brick Shed/Copper Sulfate Building: Built 1917 (wood and steel frame, brick and metal clad); 5,824 sq. ft.

Copper sulfate was produced here, originally. After the Electrolytic Silver Refinery came into production in 1978, bricks that were used by the bricklayers in various plant areas were stored here.

10.) Silver Refinery Addition and Extension: Built 1954 (wood and steel frame, metal clad); addition 1980 (CMU [concrete masonry unit]); 6,006 sq. ft.

This building was initially a brick shed for the bricklayers. It became the site of the Electrolytic Gold and Silver Refinery in 1978; the extension housed Silver Refinery Melting (a new induction furnace), Casting and Shipping.

11.) Retort Building: Estimated built 1917 (wood and steel frame, metal clad); 2,940 sq. ft.

The retort furnaces used in refining silver were situated in this building.

13.) Silver Refinery: Built 1917 (wood and steel frame, brick clad); 4,364 sq. ft.

This was the original Silver Refinery. In its final years of operation, it contained the cupels and furnaces used in cupelling the silver bullion.

14.) Lead Refinery: Built 1916-18 (wood and steel frame, metal clad); addition 1929; 28,351 sq. ft.

Blast Furnace lead bullion was drossed, softened, and refined in this building. The pure lead was cast for shipping, and byproducts from the drossing and softening were processed for recovery of antimony, copper (in matte and speiss form), and precious metals.

15.) Blast Furnace Building: Built 1916-18 (wood and steel frame, metal clad); additions 1941, 1945 (wood and steel frame, metal clad); 18,720 sq. ft.

A charge composed of sinter, coke, and flux materials was introduced into the Blast Furnace, where it was reduced into slag and lead bullion components. Prior to 1943, the slag was deposited at a slag dump outside of the Blast Furnace; the bullion was run into pots for transport by crane into the Lead Refinery.

16.) Slag Fuming Plant: Built 1943 (wood and steel frame, metal clad); 10,762 sq. ft.

Blast Furnace slag that had been formerly dumped was treated for recovery of zinc oxide and leaded zinc oxide byproducts; the slag dump was also reworked for its zinc.

18.) Fuming Plant Baghouse: Built 1943 (wood and steel frame, metal and wood clad); 8,888 sq. ft.

The zinc oxide (from the deleading circuit) and leaded zinc oxide fume from the Fuming Plant furnace was fed by balloon flues into hairpin cooling towers. It was finally exhausted into the Baghouse, where the oxide byproduct was captured. The balloon flues were 8 ft. and 10 ft. in diameter, and the brick stack that exhausted tail gases was 17 ft. diameter (base), 8 ft. diameter (top), and 200 ft. tall.

20.) Sinter Sizing Building: Built 1970 (steel frame, metal clad); removed post-1982.

Sinter produced by the Lurgi sintering machine was prepared into properly sized Blast Furnace feed here. Undersize was recycled to the Sinter Feed circuit.

22.) Sulfuric Acid Plant Baghouse: Built 1971 (reinforced concrete); 2,005 sq. ft.

After cooling, SO_2 gas from the Lurgi sintering machine was exhausted through this facility for removal of particulates, prior to conversion of the gas into H_2SO_4 at the Acid Plant.

23.) Sulfuric Acid Plant: Monsanto Acid Plant, erected 1970.

The Acid Plant included various reaction and temperature control vessels, tanks, pumps, and cooling systems. It had a steel frame and CMU Control Building, 921 sq. ft. Byproduct H_2SO_4 was produced by this facility.

24.) Effluent Water Treatment Plant: Built 1970 (materials not listed); 1,000 sq. ft.

Effluent from slag conveying (to the Ore Preparation Plant), the Sinter Sizing Building, the Crushing Plant, Lurgi fume strong gas cooling chamber, and weak acid runoff from the Acid Plant were treated in this plant's process equipment.

26.) Crushing Plant: Built 1952 (wood and steel frame, wood clad); 10,108 sq. ft.

The minor crude ore receipts and large volumes of Blast Furnace charge diluents were crushed to proper size for further treatment in the Ore Preparation Plant.

27.) Ore Preparation Plant: Built 1952 (wood and steel frame, reinforced concrete, wood clad); 19,296 sq. ft.

Sinter feed was stored, composed, and blended (by means of an impactor) in this facility.

28.) Bedding Plant: Built 1952 (steel frame, wood clad); 12,288 sq. ft.

Four bedding piles of prepared sinter feed were formed here to supply the Pelletizing Plant with feed material.

29.) Pelletizing Plant: Built 1952 (wood and steel frame, wood clad); 4,964 sq. ft.

A pelletized charge was prepared for the Lurgi Sintering Machine here.

31.) Electric Shop: Built 1968 (steel frame, CMU, pre-engineered metal clad); 6,064 sq. ft.

Lead Smelter electricians were based here.

33.) Maintenance Offices: Built 1954 (wood frame, metal clad); addition 1964; destroyed by fire post-1982.

35.) Blower House: Built 1917 (wood and steel frame, reinforced concrete, brick and metal clad); addition 1952; 6,804 sq. ft.Compressors and blowers housed in this building were used to supply forced air to the Blast Furnaces.

36.) <u>Compressor House</u>: Estimated built 1960 (wood and steel frame, reinforced concrete, metal clad); 2,717 sq. ft.

Built on the site of a Research Lab that had been destroyed in a fire, this building contained the compressors that were used in conjunction with the Pressure Leaching (Autoclave) experiment of the sixties.

37.) <u>Cadmium Plant</u>: Built 1945 (wood and steel frame, reinforced concrete, metal clad); 8,063 sq. ft.

Cadmium sponge was produced at this plant. Initially, it was refined into metal at the Lead Refinery; after 1956, the sponge was shipped to the Zinc Plant's Cadmium Plant for refining into pure cadmium metal.

38.) <u>Dry Ore Plant</u>: Built 1939 (wood frame, wood clad); 28,536 sq. ft.

This plant was built to pre-treat ores from the "Dry Ore Belt" of the Coeur d'Alenes. These ores contained significant quantities of antimony, arsenic, bismuth, and copper; antimony was recovered as a pure metal at the former Sweeny Mill (since removed) to the north of the Dry Ore Plant. After 1946, the D.O.P. was primarily used for storage.

39.) <u>Electric Furnace Building</u>: Built 1941 (wood and steel frame, metal and wood clad); 2,690 sq. ft.

An electric induction furnace was installed here to replace the Herreshoff roaster initially used in Dry Ore Plant processing. It was later put to use in preparing Cadmium Plant feed and in antimonial (hard) lead preparation.

40.) <u>Carpenter Shop</u>: Estimated built 1935 (wood frame, metal clad); 5,307 sq. ft.

Lead Smelter carpenters were based here.

41-43.) <u>Framing Shed, Lumber Sheds</u>: Estimated built 1940 (wood frame and open frame construction); 3,185 sq. ft., 2,235 sq. ft., and 720 sq. ft. respectively.

These buildings were affiliated with Carpenter Shop activities.

46.) Coal and Coke Bins: Built 1917 (reinforced concrete bins and wooden trestle); square footage not available.

These were the original Charge Storage Bins for the Lead Smelter.

49.) Ore and Concentrate Bins: Built 1917 (steel and wood bins); square footage not available.

Incoming receipts of ore and concentrates were held here, prior to preparation and sintering.

50.) Round House: Built 1917 (wood frame, metal and wood clad); 3,956 sq. ft.

Bunker Hill Railroad rolling stock was serviced here.

51.) Sample House: Built 1917 (wood frame, reinforced concrete, wood clad); 6,561 sq. ft.

Concentrates were sampled to determine composition prior to treatment.

53.) Smelter Warehouse: Estimated built 1935 (wood and steel frame, reinforced concrete, metal clad); additions 1942 and 1949; 19,382 sq. ft.

Smelter supplies and spare parts were kept here.

54.) Machine, Boiler, & Blacksmith Shop: Estimated built 1940 (wood and steel frame, metal clad); removed post-1982.

Lead Smelter machinists, boilermakers, and blacksmiths worked out of this facility.

55.) Instrument Shop: Built 1954 (wood frame, metal clad); 1,920 sq. ft.

Instruments used in the Lead Smelter were repaired and serviced here.

58.) Fan House (Inlet Main Bag House): Built 1917 (wood frame, metal clad); 846 sq. ft.

A fan drew exhaust gases from the Brick Flue and discharged them into the Bag House.

60.) Main Bag House: Built 1917 (wood and steel frame, brick clad); 16,416 sq. ft.

Blast Furnace and Lead Refinery gases were exhausted into the seven sections (each containing 400 woolen bags) of this facility for capture of dusts entrained in the fume.

61.) Main Baghouse Fan Room: Built 1917 (wood and steel frame, brick clad); 3,720 sq. ft.

This facility contained the main fans for drawing exhaust gas from the Bag House and discharging the gas through the Main Stack.

62.) Wheelabrator Baghouse: Built 1953 (steel frame, metal clad); 1,992 sq. ft.

This was an auxiliary baghouse.

65.) Old Main Stack Fan Room: Estimated built 1917 (wood and steel frame, reinforced concrete, brick and metal clad); 1,260 sq. ft.

The fan in this facility drew exhaust gases from the Main Bag House and discharged the gases out the Old Main Stack.

69.) Autoclave (Pressure Leaching) Building: Built 1965 (steel frame, metal clad); removed post-1967.

The Pressure Leaching experiment of the sixties was conducted here.

71.) Old Main Stack: Built 1954 (reinforced concrete shell with cavity brick liner).

This 200 ft. high stack replaced the original 1917 radial brick stack at the Lead Smelter; it was abandoned in 1977, when the 715 ft. Tall Stack was put in use.

78.) Sinter Storage Bins: Built 1966 (reinforced concrete and wood); square footage not available.

This was part of the Sinter Storage/Blast Furnace Feed System in use at the Lead Smelter prior to shutdown.

85.) Tall Stack: Built 1976-77 (steel reinforced concrete with 13 ft. diameter FRP [fiberglass reinforced polyester] chimney; 715 feet tall.

87.) Slag Treatment Trestle: Built 1943 (steel frame); 600 ft. long.

This trestle supported the pipe that carried granulated slag to the stockpile on the valley floor.

92.) Lurgi Sintering Machine: Erected 1970 (structural steel); 8 ft. wide by 122 ft. long.

This updraft sintering machine replaced the ten downdraft Dwight & Lloyd Machines formerly used in preparing a sinter feed for the Blast Furnace. The D. & L. facility was demolished when the Lurgi was put in operation. The machine produced SO_2 of a sufficient concentration to permit the production of byproduct H_2SO_4.

96-104.) High Velocity Flue Components: Built 1976-77 (structural steel); dimensions not available.

Push fans blew exhaust gases through this system into the Bag House, and pull fans drew the gases from the Bag House and out the Tall Stack. The H.V.F. system replaced the original Brick Flue.

109.) Brick Flue: Built 1917 (brick and structural steel); dimensions not available.

This was part of the original exhaust system for the Lead Smelter. It was abandoned in place in 1977.

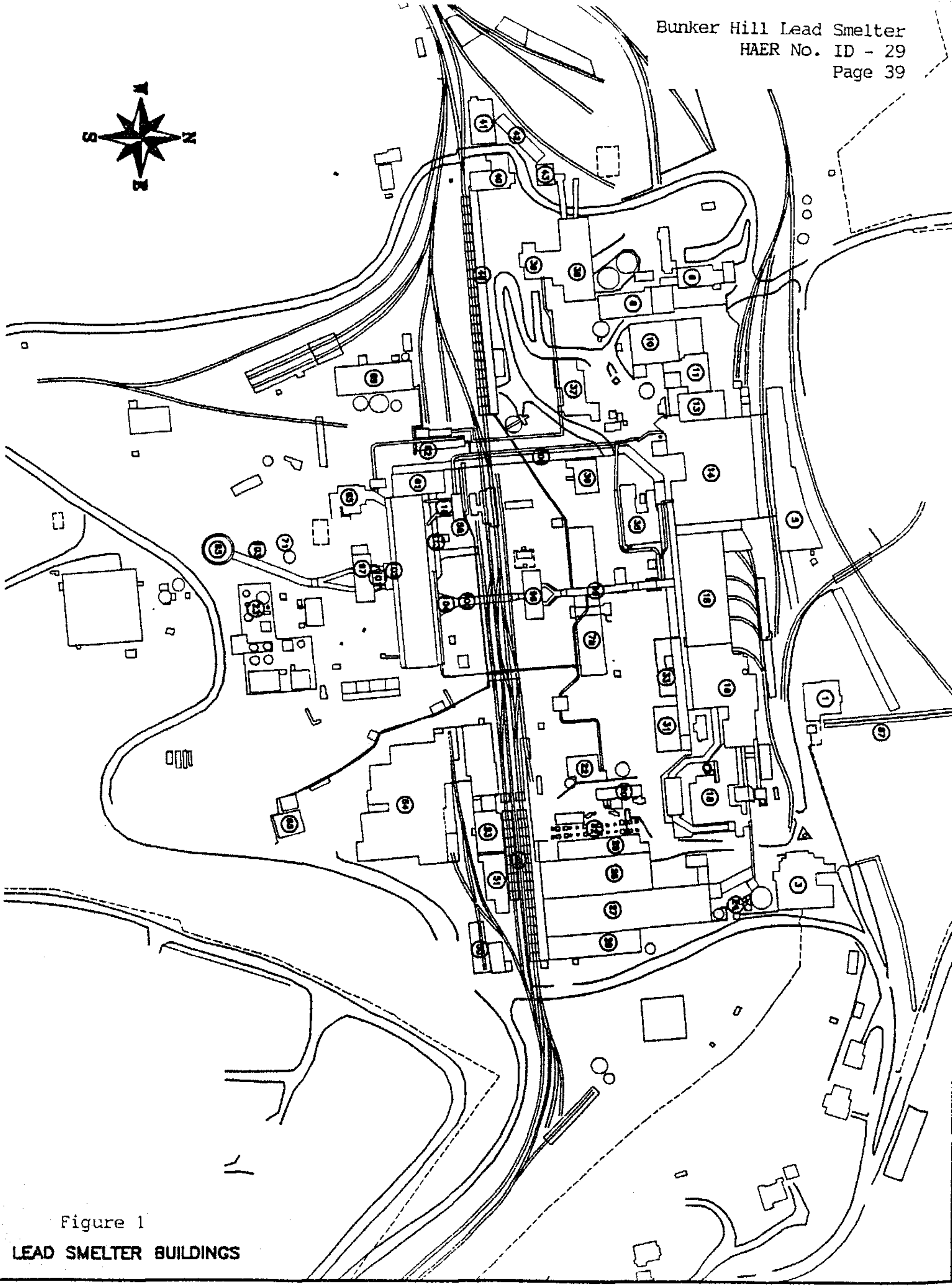


Figure 1

LEAD SMELTER BUILDINGS

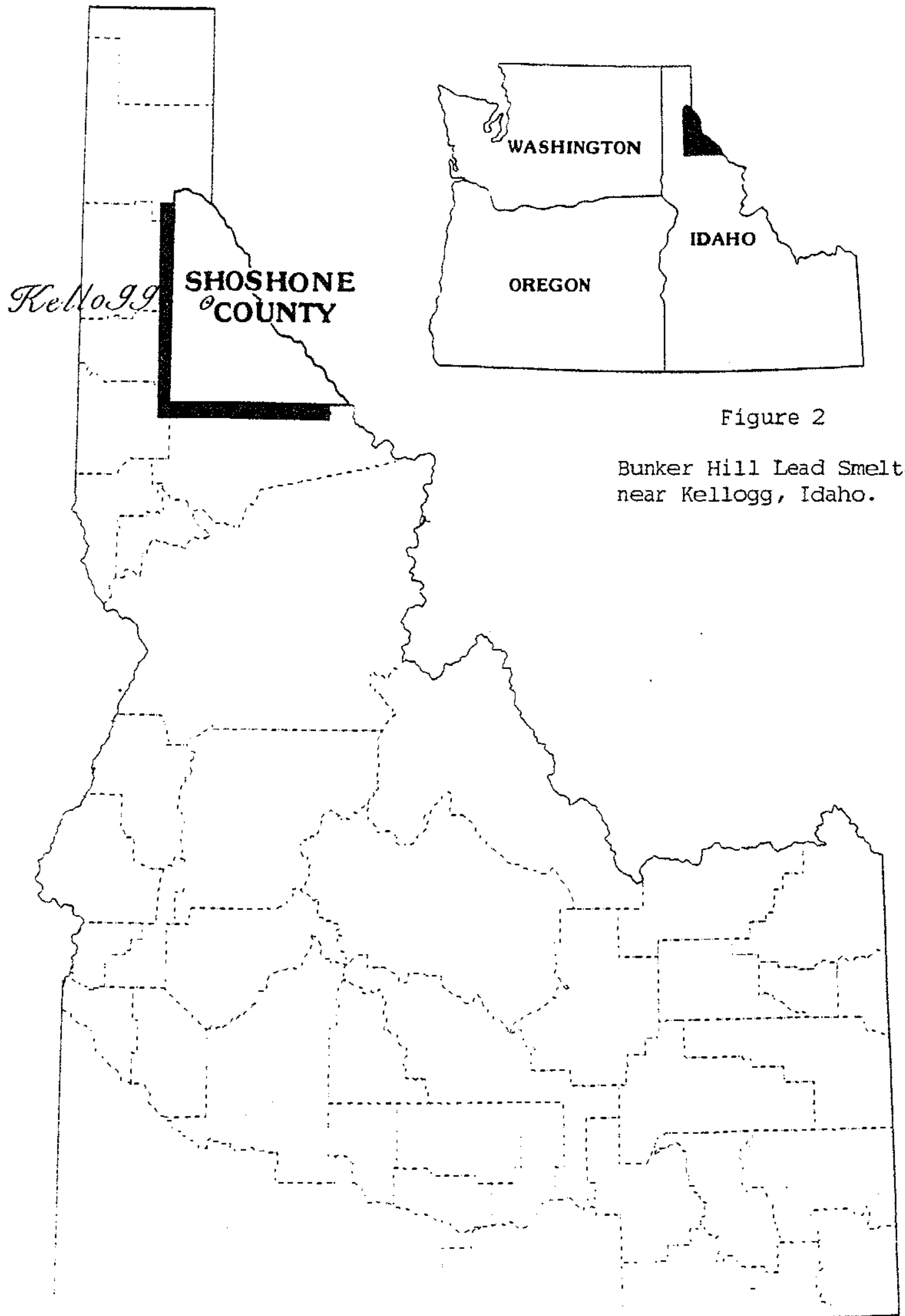
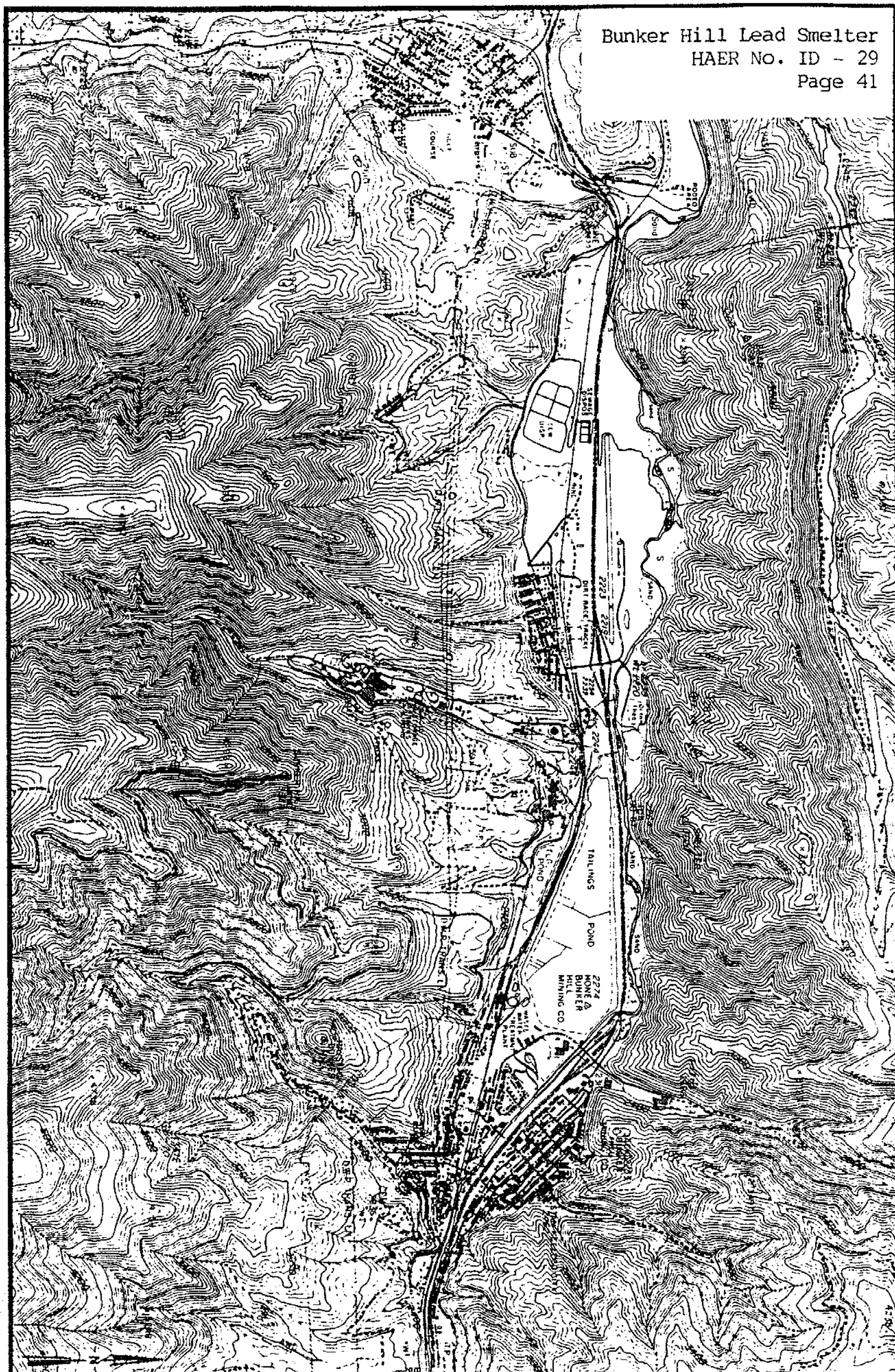


Figure 2

Bunker Hill Lead Smelter near Kellogg, Idaho.



Scale in miles

Figure 3
Kellogg Area

1 = Bunker Hill Lead Smelter
2 = North Idaho Phosphate Co.
3 = Sullivan Electrolytic Zinc Plant

K = Kellogg
S = Smelterville

NOTES

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2.Richard G. Magnuson, Coeur d'Alene Diary, (Portland: Binford & Mort Publishing, 1968), 15-16.

3.Katherine G. Aiken, "Bunker Hill versus the Lead Trust, The Struggle for Control of the Metals Market in the Coeur d'Alene Mining District 1885-1918," Pacific Northwest Quarterly 84, no. 2 (1993), 44.

4.Ibid, 5.

5.James E. Fell, Jr., Ores To Metals, The Rocky Mountain Smelting Industry, (Lincoln: University of Nebraska Press, 1979), 152,155. Ore from that section of the Coeur d'Alenes known as the "dry ore," or Silver belt, fit this distinction (Ken Kirkpatrick, Bunker Hill research metallurgist, retired, interview by author, 23 February 1993, Kellogg, Idaho).

6.Ibid, 62, 175, 246.

7.John Fahey, The Ballyhoo Bonanza: Charles Sweeny and the Idaho Mines, (Seattle: University of Washington Press, 1965), 182, 188-189.

8.Aiken, "Bunker Hill versus the Lead Trust," 46.

9.Earl Bennett, U.S. Geological Survey, University of Idaho, "Day Mines," 8, in "Historical Corporate and Operational Data- Coeur d'Alene District Mining Firms," undated draft copy of unpublished work, Pintlar Documents Storage Record (hereinafter P.D.S.R.).

10.Aiken, "Bunker Hill versus the Lead Trust," 44.

11.R.S. Handy, "The Evolution of the Mill Flowsheet," in "The Bunker Hill & Sullivan Enterprise Today," Engineering and Mining Journal 140, no.8 (1939), 53.

12.Fell, Ores To Metals, 37.

13.Frederick Bradley to Myron Folsom, 1 April 1914, P.D.S.R.

14.Aiken, "Bunker Hill versus the Lead Trust," 46, 48.

15.Myron Folsom to Frederick Bradley, 10 September 1914, P.D.S.R.

16.Frederick Bradley to Myron Folsom, 10 November 1914, P.D.S.R.

17.Jules Labarthe, "Report of an Investigation Pertaining to the Smelting and Refining of Product from Bunker Hill and Sullivan Mining and Concentration Co., Kellogg, Idaho," 2-3, unpublished report issued by Bradley, Bruff, and Labarthe, Designing and Construction Engineers, San Francisco, California, 30 June 1915, P.D.S.R.

18.Ibid, 4-7, 9-12.

19.Frederick W. Bradley, handwritten note regarding 25 September 1915 correspondence with S.A. Easton, in Bradley's copy of Labarthe's "Report of an Investigation Pertaining to the Smelting and Refining of Product," 13-B, P.D.S.R.

20.Rickard, The Bunker Hill Enterprise, 77. Crocker was a member of the influential Crocker banking family, which had been closely associated with Bunker Hill since 1891.

21.Jules Labarthe, "Report of Investigations Regarding Smelter Sites for the Bunker Hill & Sullivan Mining and Concentrating Co.," 7, unpublished report by the engineering firm of Bradley, Bruff, and Labarthe, San Francisco, California, 23 December 1915, P.D.S.R.

22.no author stated, "Lead Smelting Developments in the Coeur d'Alene," Engineering & Mining Journal 100, no.14 (1915), 572.

23.Frederick Bradley to Myron Folsom, 15 February 1916, P.D.S.R.

24.Charles Hebberd to Frederick Bradley, 1 April 1916, P.D.S.R.

25.Aiken, "Bunker Hill versus the Lead Trust," 49. Tentative agreement was reached on March 20, 1918.

26. Stanly Easton, "Twenty-Ninth Annual Report for the Year Ending December 31, 1915," Bunker Hill & Sullivan Mining & Concentrating Company, 13.

27.Myron Folsom to Frederick Bradley, 24 February 1916, P.D.S.R.

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29.Albert I. Goodell, "Re. Smelter Site," memorandum to Bunker Hill & Sullivan Mining & Concentrating Company, 17 May 1915, P.D.S.R.

30."Agreement Between The Bunker Hill & Sullivan Mining & Concentration Co., Kellogg, Idaho, and Bradley, Bruff, & Labarthe, Engineers, San Francisco, Cal.," 27 September 1915, signed by F.W. Bradley (Bunker Hill) and G.O. Bradley (Bradley, Bruff, & Labarthe), P.D.S.R.

31.Stanly Easton to Jules Labarthe, 15 May 1916, P.D.S.R.

32.Jules Labarthe to Stanly Easton, 16 May 1916, P.D.S.R.

33.Stanly Easton to Jules Labarthe, 13 November 1916, P.D.S.R.; Stanly Easton to Jules Labarthe, 23 November 1916, P.D.S.R.

34.Stanly Easton to Jules Labarthe, 16 May 1916, P.D.S.R.

35.Jules Labarthe to Stanly Easton, 30 May 1916, P.D.S.R.

36.Jules Labarthe to Stanly Easton, 8 August 1916, P.D.S.R.

37.Jules Labarthe to Stanly Easton, 15 June 1917; Myron Folsom to Harry L. Day, 26 April 1917; and Harry L. Day to Myron Folsom, 1 May 1917 (all P.D.S.R.).

38."New No.1 Blast Furnace Blown In," Bunker Hill Reporter 2, no.4 (1957), 3. The Bunker Hill Reporter was a monthly newspaper issued by The Bunker Hill Company's Employee and Public Relations Division between 1956 and 1976. Bound copies are on file at the Kellogg Public Library, Kellogg, Idaho.

39.Rickard, The Bunker Hill Enterprise, 109.

40."Bunker Hill Smelter Contracts," Bunker Hill & Sullivan Mining & Concentrating Co., P.D.S.R.

41.Rickard, The Bunker Hill Enterprise, 108.

42.Jules Labarthe to Dwight & Lloyd Sintering Co., 9 February 1918, P.D.S.R.

43.R.L. Lloyd to Jules Labarthe, 4 March 1918, P.D.S.R.

44.T.A. Rickard, The Bunker Hill Enterprise, 114.

45.Ibid, 115.

46.G.O. Bradley to N.D. Phelps, 23 May 1916, P.D.S.R.

47.Rickard, The Bunker Hill Enterprise, 112.

48.Rickard, The Bunker Hill Enterprise, 115.

49.Rickard, The Bunker Hill Enterprise, 120.

50.Rickard, The Bunker Hill Enterprise, 120.

51.Rickard, The Bunker Hill Enterprise, 120. Rickard notes that the initial desilverizing operation was performed with zinc from the Anaconda Copper Mining Company's Great Falls, Montana electrolytic zinc plant.

52.Rickard, Bunker Hill Enterprise, 123.

53.Ibid.

54.Ibid.

55.Ibid.

56.George Holman to Frederick Bradley, 18 August 1918, P.D.S.R.

57."Bunker Hill & Sullivan Mining & Concentrating Company", a 186 page 1920 summary of Company operations, 5-8, P.D.S.R.

58.Ibid, 70-83.

59.Clinton H. Crane, Chairman, Lead Producers Committee, "To All Whom It May Concern," memorandum received by Bunker Hill, 20 August 1918, P.D.S.R.

60.Michael H. Sullivan to Bunker Hill & Sullivan, San Francisco, telegram of 9 November 1918, P.D.S.R.

61.Jules Labarthe to Frederick Bradley, 11 March 1918, P.D.S.R.

62.Rickard, The Bunker Hill Enterprise, 112, 115.

63.Frederick Bradley to Stanly Easton, 29 May 1923, P.D.S.R.

64.Stanly Easton, "Thirty-Seventh Annual Report for the Year Ending December 31, 1924," Bunker Hill & Sullivan Mining & Concentrating Company, 5.

65.M.H. Sullivan and F.M. Smith, "Request for Appropriation," 14 November 1925, P.D.S.R.

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67.Stanly Easton, "Forty-Second Annual Report for the Year Ending December 31, 1929," Bunker Hill & Sullivan Mining & Concentrating Company, 5.

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69.A.F. Beasley, "The Bunker Hill Smelter- A Modern Plant," in "The Bunker Hill & Sullivan Enterprise Today," Engineering & Mining Journal 140, no.4 (1939), 63.

70.R.G. Hall to Harmon E. Keyes, 9 January 1932, P.D.S.R.

71.Beasley, "The Bunker Hill Smelter," 61, 63, 65-68.

72.Ibid, 65.

73.Ibid.

74.Ibid, 68.

75.Ibid, 68.

76.Joe Hauser, interview by author, 19 February 1993, Kellogg, Idaho; Ken Kirkpatrick, interview by author, 23 February 1993, Kellogg, Idaho; Lawrits Larsen, interview by author, 23 March 1993, Kellogg, Idaho.

77.Ray Hasz, interview by author, 19 May 1993, Kellogg, Idaho.

78.Kirkpatrick, 23 February 1993; Virgil McKenzie, interview by author, 9 March 1993, Kellogg, Idaho.

79.Cordy Haushild, interview by author, 7 April 1993, Kellogg, Idaho.

80.Stanly Easton and John D. Bradley, "Sixty-Eighth Annual Report for the Year Ending December 31, 1955," Bunker Hill & Sullivan Mining & Concentrating Company, 5; John D. Bradley, "Seventieth Annual Report for the Year Ending December 31, 1957," The Bunker Hill Company, 5. Upon combining ownership of the Zinc Plant, Lead Smelter, and Mine, the corporate name was formally changed to "The Bunker Hill Company."

81.Stanly Easton to Jules Labarthe, 7 March 1916, P.D.S.R.

82.Harold E. Lee and Donald Ingvoldstad, "Modernization of Bunker Hill Presintering Practices," AIME Transactions 206 (1956), 1469.

83.Ibid, 1470.

84.Ibid, 1471.

85.Ibid, 1472-73.

86.Ibid, 1473.

87.Gene Pierce, interview by author, 25 August 1993, Pinehurst, Idaho; Stanly Easton, "Sixty-Third Annual Report for the Year Ending December 31, 1950," Bunker Hill & Sullivan Mining & Concentrating Company, 6.

88.Joe Hauser, interview by author, 5 April 1993, Kellogg, Idaho.

89.J. E. McKay, "Lead," 230-31, in Lead Metallurgy, Volume 12, (New York: John Wiley and Sons, 1966).

90.Ibid, 231.

91.Ibid.

92.Stanly Easton and John D. Bradley, "Sixty-Ninth Annual Report for the Year Ending December 31, 1956," The Bunker Hill Company, 15.

93.Hauser, 19 February 1993.

94.Larsen, 23 March 1993.

95."Company's Plants Switching to Gas," Bunker Hill Reporter 2, no.6 (1957), 1.

96."Pilot Plant Sintering Machine Now in Operation at Smelter," Bunker Hill Reporter 3, no.7 (1958), 1.

97.Ted Turnbow, interview by author, 6 May 1993, Kellogg, Idaho. Mr. Turnbow was a Supervisor of Mechanical Maintenance at Bunker Hill, and he was involved with the maintenance of the equipment used in pressure leaching.

98.Turnbow, 6 May 1993.

99.McKay, "Lead," 214.

100.Ibid.

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103."Pilot Plant Sintering Machine Now in Operation," B.H.R., 1.

104.Jasberg, 26 August 1993.

105.Ibid.

106.Morgan P. McKay to James E. Gyde, 6 January 1950, P.D.S.R.

107."Acid Plant," 19-3, in "Operating Accounts (All Plants)-Smelter Operations Data," unpublished Bunker Hill Company manual (1975), P.D.S.R.

108.Jasberg, 26 August 1993.

109."Acid Plant," 19-1, 5, in "Operating Accounts (All Plants)-Smelter Operations Data," unpublished Bunker Hill Company manual (1975), P.D.S.R.

110.Bunker Hill Company, "Outline of Significant Dates in Bunker History," company chronology, 4, P.D.S.R.

111.Charles Schreier, interview by author, 30 August 1993, Kellogg, Idaho. Mr. Schreier, who worked at the Silver Refinery at this time, said that Bunker Hill learned of copper's effect on crystal formation from the Homestake Mining Company of Lead, South Dakota.

112.Ibid.

113.Ibid.

114.Fell, Ores To Metals, 273.

115.Stanly Easton to Jules Labarthe, 29 March 1917, P.D.S.R.

116.John Macri, interview by author, 30 August 1993, Kellogg, Idaho. Mr. Macri had a forty-year career at the Lead Smelter's Silver Refinery and Mechanical Maintenance Shop.

117.Rickard, Bunker Hill Enterprise, 124; Easton to Labarthe, 29 March 1917.

118.Herman Liepold, interview by author, 30 August 1993, Smelterville, Idaho. Mr. Liepold was a 44 year veteran of the Lead Smelter, and he succeeded Mr. Triča as a Blast Furnace foreman.

119."M. H. Sullivan Dies From Auto Wreck Injuries Received While Enroute to Wallace February 1," Kellogg Evening News, Kellogg, Idaho, 13 February 1928. Holdings of this newspaper are on microfilm at the Osburn Public Library, Osburn, Idaho.

120.Ray Chapman, interview by author, 1 September 1993, Kellogg, Idaho.

121.Macri, 30 August 1993.

122."Lead Smelter 20-Year Club Meets; All Plants Now Have Service Groups," Bunker Hill Reporter 8, no. 5 (1963), 1.

123.Variations of the "Smelter City" masthead appeared in the Kellogg Evening News from its inception as a daily newspaper on March 12, 1924 until 1985, when the newspaper was renamed the Shoshone County News-Press (microfilm holdings of Kellogg Evening News, Osburn Public Library, Osburn, Idaho).

124.Charles P. Blickle, "Exhibit B: Schedule of Buildings and Land Improvements- Construction Smelter," 18-21, in "Appraisal Report-The Bunker Hill Company," Milwaukee: American Appraisal Company, 1977; "Lead Smelter Demolition Building Location, Bunker Hill Superfund Site," Pintlar Corporation, (Drawing no. 92-GM-00019), Kellogg, Idaho, 17 December 1992, P.D.S.R.

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